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COMMERCIAL CABBAGE CULTURE

By

VICTOR R. BOSWELL

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Division of Horticultural Crops and Diseases
Bureau of Plant Industry

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INTRODUCTION

Cabbage has been used as human food for probably 4,000 years. It was used by the ancient Greeks and Egyptians and has been grown by Europeans for about 1,000 years. The early forms were doubtless quite different from present varieties, which, together with cauliflower, kale, and other related forms, have been developed from wild types presumably similar to the wild cabbage that is found growing at present on the chalk cliffs of England, on the seacoasts of Denmark, in northwestern France, and in other similar regions of Europe.

Cabbage is a member of the mustard family and a botanical variety of the species *Brassica oleracea.* It is closely related botanically to other members of the species, such as kale, collards, cauliflower, Brussels sprouts, broccoli, and kohlrabi and will cross readily with them.

COMPOSITION AND FOOD VALUE

According to Chatfield and Adams (*9*),[1] the average composition of cabbage is as follows: Water, 92.4 per cent; protein, 1.4 per cent; fat, 2 per cent; ash, 0.75 per cent; fiber, 1 per cent; and sugars, 3.5 per cent. The fuel value per pound of the edible portion is 130 calories, but on account of the parts discarded as waste in preparing cabbage for the table, the fuel value per pound as it is purchased or prepared for market is about 90 calories. This fuel value compares favorably with that of asparagus, broccoli, beet greens, chard, mustard, cauliflower, spinach, tomatoes, and eggplant, but is somewhat lower than the value of beets, carrots, and onions. Such vegetables as beans, peas, sweet corn, and potatoes are much higher in fuel value than cabbage.

Although relatively low in fuel value, cabbage when raw is particularly rich as a source of vitamins B and C. The green leaves are also rich in vitamin A, but the blanched or white leaves contain only a small amount. Results of studies by Smith (*23*) show that green raw cabbage compares favorably with lettuce and tomatoes as a source of all three vitamins; it is superior to asparagus, beet, eggplant, and onions, in content of B and C, and contains more of A and C than snap beans, beets, carrots, cauliflower, eggplant, and onions.

RANGE OF CULTURE AND COMMERCIAL IMPORTANCE

Cabbage is grown throughout the United States except in regions in which no vegetables can be grown. The large commercial plantings are found in locations especially favorable because of fertile soil or suitable climate. It is grown as a winter and early spring crop in the South and as a summer or fall crop in the Northern States and at high altitudes.

The influence of temperature and rainfall upon the growth of cabbage is very pronounced and determines to a large extent the principal regions for growing. Although the crop is grown to a fair extent on nonirrigated lands of the Middle West, the most extensive nonirrigated areas are not far distant from the Great Lakes or in the Atlantic States where the rainfall averages 35 to 40 inches or more per year and is well distributed throughout the growing season. Light soils and soils deficient in organic matter are not suitable for cabbage culture in regions of low water supply because they have such low water-holding capacity that the crop suffers severely from a deficiency of water. Cabbage requires an abundant and reasonably uniform supply of moisture.

In commercial acreage cabbage ranks seventh to ninth among vegetables grown for market or canning and manufacture, being surpassed by tomatoes, sweetpotatoes, sweet corn, early potatoes, peas, and watermelons, and in some years by snap beans and cucumbers. In value the cabbage crop ranks sixth or seventh, generally being exceeded by sweetpotatoes, tomatoes, early potatoes, lettuce, and peas, and sometimes by muskmelons. The commercial acreage varies from about 120,000 to 155,000 acres in different years; annual production is in the neighborhood of a million tons, and the value of the crop varies from about $17,000,000 to $20,000,000 annually.[2]

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[1] Italic numbers in parentheses refer to Literature Cited, p. 57.

[2] Detailed data on acreage, production, and values can be obtained by writing to the Bureau of Agricultural Economics, U. S. Department of Agriculture, Washington, D. C.

PURPOSES FOR WHICH CABBAGE IS GROWN

In separate regions the crop is produced to be used for specific purposes and to be handled and marketed by different means. These various types of commercial culture of cabbage for different objects or purposes may be listed as follows:

In the vicinity of towns or cities the crop is grown in small market-garden or truck areas and is intended for immediate local consumption. Such developments are not confined to one region in the country but are well distributed over it.

In extensive truck-crop areas, roughly in the southern third of the country, cabbage is grown so as to reach the harvest stage in the winter or early spring, the crop being intended for shipping considerable distances northward in the fresh green state. The more important of these regions are in the central and southern parts of Florida and Texas, in California, Louisiana, Mississippi, Alabama, South Carolina, Virginia, and Maryland.

Cabbage is grown on a large scale as a summer or fall crop in central and western New York, Wisconsin, Ohio, Michigan, and north-central Colorado. Part of this crop is marketed for use immediately after being harvested, but most of it is either stored for distribution through the fall and winter or is manufactured into sauerkraut.

More detailed information upon the location of the important cabbage-growing localities will be found in United States Department of Agriculture Department Bulletin No. 1242, Marketing Cabbage (*8*).

PURPOSE AND SCOPE OF THIS CIRCULAR

In this circular no attempt is made to present a comprehensive description and review of the details of cultural methods and field practices that prevail in different regions. Anyone contemplating the culture of cabbage in any part of the country where the crop is commonly grown can easily observe the details of culture that experience has shown to be fairly satisfactory in that particular locality, and some such actual contact with growing operations is essential to a working knowledge of the crop in each general region where it is grown. The purpose here is to present a few typical practices together with some less commonly known information and principles which will afford a sound basis for successful production. This information has been drawn from practice and scientific investigations in many States. The individual grower must adapt these principles and facts to his own local conditions, guided by his own experience and that of others in the locality.

The more elementary points in the culture of cabbage are covered in Farmers' Bulletin No. 1673, The Farm Garden (*4*).

EFFECTS OF TEMPERATURE

GENERAL EFFECTS

Cabbage is a cool-season plant that makes its best development in the spring or fall in most regions of this country. Only in the Northern States or at high altitudes does it succeed when planted so that most of its growth occurs during the summer. Even though an abundance of plant food and water is available, normal growth and head formation will not result if the temperatures are high for a period of weeks, especially during the latter half of the time usually required for a variety to reach the market stage. Temperatures between 95° and 100° F., which commonly occur through the southern

two-thirds of the country in midsummer, are distinctly harmful, especially if the nights also are warm. If the nights are usually quite cool, as in regions of high altitude, high temperatures for a few hours during the day are not particularly harmful.

The dates for sowing and transplanting which prevail in each region where the crop is grown commercially have been adopted through trial and error, and are carefully adapted so that excessive temperatures generally will be avoided during the later part of the plant's growth. Long-season or late varieties such as Danish Ballhead, Late Flat Dutch, and Wisconsin Hollander are apparently unsuited to those parts of the country in which the mild growing weather of spring quickly gives way to the intense heat of summer, and in which the winter is too cold for growth. Only rapidly developing sorts like Early Jersey Wakefield, Copenhagen Market, and Glory of Enkhuizen are suited to such regions.

Cabbage is hardy to cold if grown under a gradually lowering temperature such as normally occurs in the fall. Under these conditions it will endure light freezes without injury, but unseasonable frosts that sometimes occur during a period of otherwise warm weather and during the fairly rapid growth of the plants usually cause severe injury or death. Small plants grown in the fall and subjected to a gradual lowering of temperature become exceedingly resistant to cold, being able to withstand a temperature of 10° F., and for short periods under conditions not too unfavorable even as low as 0°.

EFFECTS ON PREMATURE SHOOTING TO SEED

In those Middle Atlantic and Southern States where cabbage is planted in the fall and carried over winter in the open field, an appreciable percentage of the plants may "shoot to seed" in the spring instead of forming heads, largely as a result of temperature conditions. This premature formation of flower stalks is a more common trouble in Maryland, Virginia, and the Carolinas than in the cabbage regions of the Gulf States. In Maryland, Virginia, and the Carolinas a small percentage of "seeders" usually is expected, but in some seasons it may be as high as 60 to 70 per cent of the plants in the field, or even more. Premature seed-stalk formation sometimes occurs in fields of cabbage that are transplanted in the spring, but serious losses are not common. It must be emphasized that when seeders become evident in a field of cabbage it is too late to correct the trouble. When the plant has developed into a seeder to the extent that seed stalks are visible, there is no practical way of changing it into a type of plant that will form a good marketable head. Therefore it is important that the grower understand the conditions which cause premature seed-stalk formation, or "bolting" as it is often called, so that the trouble can be prevented so far as possible. Unfortunately, it can not always be prevented.

Cabbage is a biennial plant; that is, it normally requires two seasons, or parts of two seasons, in which to complete its development from the seedling stage to the formation of flowers and maturing of seeds. Under favorable conditions in the first season of growth the plant forms a rosette of leaves and a head; that is,

a compact arrangement of leaves about the upper part of the stem of the plant. Miller (*21*), working at the agricultural experiment station of Cornell University, has shown that if it is desired to obtain seed from plants that have formed heads, these plants must have a period of rest of about two months under conditions of temperature low enough to stop temporarily outward evidences of growth, but not necessarily cold enough to freeze the plant. Upon raising the temperature to that similar to good growing weather in the spring, flower stalks, flowers, and finally seed will be produced. Merely checking the development of the plants by withholding water, or by other means, at a warm temperature (60° to 70° F. or higher) will not result in flower and seed development. A cool temperature, as low as 40° to 50° F., is absolutely necessary, and even lower temperatures may be effective.

Small cabbage plants also behave in a similar fashion. It is not necessary for a plant to develop to the heading stage before flower-stalk formation can be induced by a period of low temperature which is followed by good growing conditions. This is well known because of the occurrence of "premature seeders" or bolters in the field. The question arises, then, Why do only 10, 20, or perhaps 50 per cent of the plants in a field produce seed stalks in certain seasons? If cold weather causes bolting, as well as being necessary for seed formation in headed plants, why do only part of the plants in the field go to seed prematurely?

OVERWINTERED CABBAGE

Studies of the problem of overwintering by Boswell (*6*) in Maryland have shown that the size attained by the plant at the time it is exposed to cold is of very great importance in determining whether or not a "seeder" will result in the spring. Plants with stems larger than one-fourth inch bolted very badly; the larger the plants, the more of them bolted. For example, of plants with stems three-eighths of an inch in diameter at the thickest point, roughly one-half bolted, and in some instances as many as three-fourths of them produced seeders instead of heads. Plants with maximum stem diameters of approximately three-sixteenths to one-fourth inch rarely produced over 10 per cent of seeders and usually 4 to 7 per cent. Plants with stems smaller than three-sixteenths inch produced practically no seeders, but if noticeably smaller than three-sixteenths inch they were very susceptible to winterkilling. Thus, in regions where cabbage is overwintered under low temperatures and there are protracted periods with the temperature around 40° F. or down to freezing or lower, a higher percentage of bolters may be expected among plants that have stems larger than a lead pencil (approximately three-sixteenths to one-fourth inch).

Sometimes plants of fairly large size (one-fourth to five-sixteenths inch stem diameter) do not produce seed stalks as much as stated in the preceding paragraph, even though the temperature has been low for many weeks during the winter, but in general the hazards are great. It is considered good insurance to use plants no larger than three-sixteenths to one-quarter inch if there is any probability

of their being exposed to low temperature for more than two weeks, either before or after transplanting.

Fertilizer treatment in the plant bed is without effect on bolting except as it affects the size of the plant; but heavy fertilizing in the plant bed does produce many plants that are too large, which results in a high percentage of seeders if the weather conditions are such as to induce bolting. Fertilizer treatment in the field is apparently without any effect whatever because it does not influence growth appreciably until after the periods of low temperatures are past.

Even though it is known that bolting of overwintered cabbage is closely associated with the size of the plants at the time cold weather arrives, it is not always possible to control the size of the plants in the plant bed as desired. Sowing the seed as late as it is possible to still obtain strong, vigorous, winter-hardy plants and the using of fertilizers judiciously so as to avoid having the plants attain excessive size, are the best means of control that are at the grower's disposal. However, if the fall season happens to be unusually warm, or growing weather continues unusually late, as it sometimes does, the plants may grow too large in spite of careful planning and management. At present no practicable treatment is known which will reduce the tendency of such plants to shoot to seed. On the other hand, cold weather may arrive unusually early, stopping the growth of plants in the bed while they are so small that they will be severely injured by the colder weather that follows.

The only practicable means of assuring a supply of plants of proper size through avoiding the undesirable results of either unusually early or unusually late cold weather is to make two sowings of seed a week or two apart. The dates of sowing depend upon the normal weather conditions in the regions in question. The sowings should be closer together in the Maryland and Virginia areas than in South Carolina, where the progress of winter weather is slower and where there is more latitude in suitable sowing dates. For example, the usual date of sowing in the vicinity of Baltimore, Md., is approximately September 10. In some seasons this proves to be a little too early, for the plants become too large before time for transplanting. In other seasons the opposite is true. Sowings made on September 6 and on September 14 would accomplish much to insure a supply of suitable plants. The early sowing may prove too early, and most of the plants may be so large that they will have to be discarded, but in such an event, most of the plants from the sowings of September 14 should be of suitable size. If cold weather comes earlier than usual the September 14 plants may be so small that most of them would be winterkilled and so must be discarded. Even so, a good supply of plants should be available from the September 6 sowing. It is truly remarkable how much difference in plants is obtained by only a week's difference in sowing in the Baltimore area. Farther south, the difference in planting dates needs to be greater in order to produce appreciable differences in the character of the plants grown for transplanting.

This method of avoiding premature seed-stalk formation involves the planting of approximately twice the amount of seed that would be sown for a single planting. Good cabbage seed and the growing of plants are fairly costly, but if the percentage of seeders can be held

down to 5 or 10 per cent or lower, instead of perhaps 25 or 30 per cent, the additional cost of extra seed and plant growing is usually justified. Some of the best growers follow the practice just described.

Another method that often can be used successfully to prevent the plants from becoming too large before cold weather arrives is to remove them from the plant bed and transplant them to the field just as soon as they attain the proper size, regardless of the time. This checks the development of the plants considerably, and they will grow but little, if any more, after transplanting and before winter. If this method of controlling plant size is to be used, it is obviously necessary to make plans far enough in advance to have the field available for transplanting considerably earlier than the usual transplanting date.

The Louisiana Agricultural Experiment Station recommends [3] that plants for the spring crop be started at such a time as to reach the required size for setting in the field early in January. Transplantings made before December 10 to 15 are very likely to shoot to seed severely.

SPRING-PLANTED CABBAGE

Occasionally there are severe losses in spring-sown, spring-planted cabbage, on account of bolting. This is much less common than bolting in the overwintered crop, but losses may be as high as 30 to 40 per cent in certain years. It is caused by essentially the same factors that cause bolting in the overwintered crop, but is less common because the temperature in the spring after the plants are set rarely remains low long enough to cause bolting. Furthermore, even if the weather is conducive to bolting, plants from late-winter or early-spring sowing rarely are large enough to bolt until after the period of cool weather which could induce bolting has passed. At the same time it should be remembered that some varieties bolt more easily than others. Copenhagen Market will bolt severely under conditions which disturb Early Jersey Wakefield very little. There are also pronounced differences between strains in this respect. At this time, there is little, if any, possibility of combating bolting in spring-sown cabbage except through the development of strains which do not bolt readily. Strains of Early Jersey Wakefield and Charleston Wakefield which show small tendency to bolt have been observed by Zimmerley (*30*). Unfortunately, it is not possible to refer growers to sources of such stocks, but they doubtless exist and might be located by growers' trials.

In the competition among growers to obtain earliness and high prices, it is essential to use good-sized, vigorous plants and to set them in the field as early as possible. Using smaller plants or transplanting later would doubtless greatly reduce the amount of bolting in those rare seasons when it is serious. In most seasons, however, these measures would probably serve only to delay harvest and reduce yields and profits, because in the spring-sown crop bolting is rarely serious and the effort to reduce it often will have been made for nothing. Over a period of years the chances for profit with a heavy early yield will probably outweigh the danger of loss by bolting.

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[3] Unpublished correspondence.

There is one precaution, however, that can well be taken with the spring transplanted crop. The source of the plants to be used should be definitely known. Plants that have been in a plant bed all winter, or that have endured low temperature for a period of weeks after the stems have attained the size of a pencil, should be used with caution. The size of plant should be kept down, as recommended.

The effects of temperature upon cabbage have been discussed at length because a thorough knowledge and clear understanding of the available information upon this subject are of the greatest practical value. Their importance to the cabbage grower is very strongly emphasized.

CHARACTERIZATIONS OF THE MORE IMPORTANT VARIETIES

In choosing a variety of cabbage, one should make sure that it is adapted to the region in question and that it meets the market requirements. Round varieties can be sold with difficulty, if at all, upon markets that demand pointed heads, and vice versa. Of the scores of so-called varieties of cabbage only about a dozen are needed to cover practically every commercial demand and to suit all conditions under which the crop is commonly grown. Many of the supposed distinctive characters of certain so-called varieties either do not exist at all or are so slight and so unimportant as to merit no serious consideration.

The following characterizations are intended to aid the grower in his selection of strains especially suited to his section and to the purpose for which he wishes to grow cabbage. By using these characteristics in connection with the data given in Table 1, he should be able to select desirable stocks for the climate and conditions of his region. These descriptions are adapted from data obtained by the United States Department of Agriculture in cooperation with the agricultural experiment stations of Pennsylvania, Wisconsin, California, Texas, and South Carolina, and the Virginia Truck Experiment Station.

TABLE 1.—*Outstanding characteristics of the more important varieties of cabbage, arranged in order of earliness*

Variety name	Season	Head shape	Head size	Plant size	Principal use
Early Jersey Wakefield.	First early	Very pointed	Small	Small	Market.
Copenhagen Market.	Early	Round	Medium	Medium	Market; sauerkraut.
Charleston Wakefield.	Second early	Medium pointed	Medium small	do	Market.
Early Winnigstadt	Early midseason or winter.	do	do	Large	Do.
All Seasons	Midseason	Semiflat	Medium large	do	Sauerkraut; market.
Glory of Enkhuizen.	do	Round	Large	Medium large	Do.
Late Flat Dutch	Late midseason.	Flat	do	Large	Do.
Danish Ballhead	Late	Semiround	Medium large	do	Storage.
Wisconsin Hollander (disease resistant).	do	do	do	do	Do.

Early Jersey Wakefield (fig. 1).—Early Jersey Wakefield is the earliest of the important commercial varieties. It reaches harvest generally 65 to 70 days after being transplanted in the spring.

Plant small, 10 to 12 inches in height, spreading 20 to 22 inches. Outer leaves small and few, typically 11 to 13, smooth and nearly flat near the edges, which are entire (not notched or scalloped), mostly spreading well away from the head, the head standing out very prominently; midrib and large ribs prominent in height on the under side of the leaf, but not conspicuous in color; ribs not prominent in height on the upper side of leaf, but quite noticeable on account of their very light-green color in contrast to the dark green of the other parts of the leaf; small veins quite inconspicuous; "bloom" or grayish waxy covering of the leaf slight. Head pointed, small, typically 1¾ to 2¼ pounds; about 6½ to 7¼ inches long, and 4½ to 5 inches in diameter; top bluntly pointed, not hard, but firm enough to resist damage in packing and handling; base hemispherical and hard; outermost leaves held tightly well around the head; interior rather loosely formed, with spaces between the leaves; midribs arise from the stem or core at an angle of about 45°; core small, 1 to 1½ inches in diameter and 3 to 3½ inches long, slightly less than half the length of the head.

FIGURE 1.—Early Jersey Wakefield

Some strains sold under the name of Early Jersey Wakefield are more like the Charleston Wakefield. These large, coarse types are not true to the variety.

Copenhagen Market (fig. 2).—Copenhagen Market is early; it reaches harvest 70 to 75 days after being transplanted.

Plant medium sized, about 9 to 11 inches tall, spreading 22 to 25 inches; outer leaves medium in size and number, typically 14 to 16, curving broadly outward and upward from base of plant, standing well away from head and giving plant as a whole a somewhat cup-shaped appearance; all except the very largest leaves rather uniformly curved up into the shape of the bowl of a rounded spoon; tips of leaves stand at nearly the same level above the soil and slightly above the head; leaf surfaces slightly undulate (irregularly wavy), edges slightly crenate (faintly scalloped); ribs and veins conspicuous on account of their very light yellow-green color in contrast to the medium green of the other parts of the leaf; "bloom" or grayish waxy covering moderate in amount, giving the leaves a medium-green color. Head medium sized, typically 3 to 4 pounds (much larger heads are not suitable for early market), measuring 6 to 7 inches in diameter at its equator and 5¾ to 6¾ inches from top to base; perfectly globe-shaped in appearance but actually of slightly greater diameter than depth; circular in cross section except for slight depressions at the midribs, compact and hard. Outermost head leaves lie close against those beneath but are easily removed; light yellow-green in color in marked contrast to outer leaves of plant; smaller ribs and veins prominent. Interior of head appears medium compact, with very little space between leaves; midribs arise from

the stem or core at an angle of about 40° above horizontal; core medium sized, 1¼ to 1½ inches in diameter at the middle and 3 to 3½ inches long, slightly more than half the length of the head.

This variety is probably the most important of the early sorts.

Charleston Wakefield (fig. 3).—Charleston Wakefield is a second-early variety; it reaches harvest 70 to 75 days after being transplanted in the spring.

FIGURE 2.—Copenhagen Market

Similar to Early Jersey Wakefield except that plant is distinctly larger, has more leaves, is coarser in appearance, and the heads are larger and of slightly greater diameter in proportion to their length.

Strains resembling Charleston Wakefield are sometimes sold as Early Jersey Wakefield.

Glory of Enkhuizen (fig. 4).—Glory of Enkhuizen is an early midseason variety; it reaches harvest 80 to 90 days after being transplanted in the spring.

Plant large, 13 to 14 inches tall, spreading 30 to 34 inches; leaves many, 17 to 20, and large, but forming a low proportion (about 30 per cent) of the

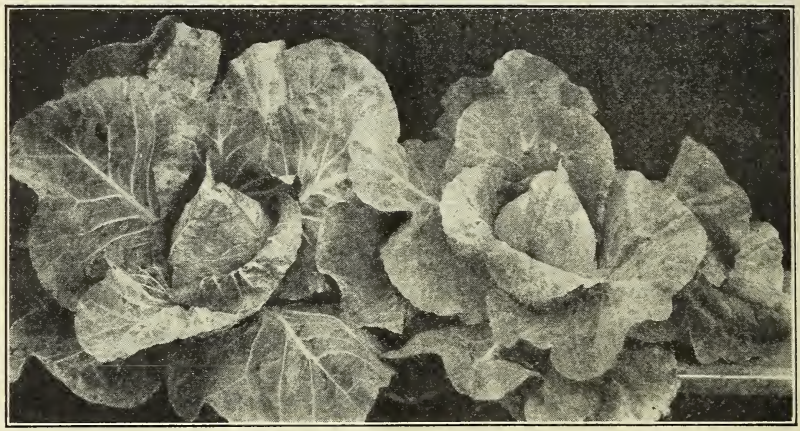

FIGURE 3.—Charleston Wakefield

total plant weight because of a proportionally large head; very similar to Copenhagen Market in general appearance except distinctly larger, and "bloom" or grayish waxy covering of the leaves is slightly heavier, giving the leaves a medium grayish-green color. Head almost globular, large, typically 6 to 7½ pounds, compact and hard, and constituting about 70 per cent (an unusually high proportion) of entire plant; measuring 7½ to 8½ inches in diameter at its equator and 7 to 7½ inches from top to base (very large heads, weighing 10 to 12 pounds, are sometimes grown for sauerkraut, but this is

too large for market). Outer head leaves reach slightly past the center of the top and well around the sides, lying tightly against the underlying leaves; ribs and veins prominent in height, ribs being lighter in color than the other parts of the leaf. Head color medium yellowish green, in moderate contrast to outer-leaf color; "bloom" light. Interior of head similar to Copenhagen Market in appearance except that the stem or core is proportionally smaller, measuring 1¼ to 1½ inches in diameter at the middle and 3 to 3½ inches long, and reaching slightly less than halfway to the top of the head.

It is popular for early midseason shipping and also as a later crop for sauerkraut manufacture.

All Seasons (fig. 5).—All Seasons reaches harvest 90 to 95 days after being transplanted in the spring or early in the summer.

Plant very large, 13 to 15 inches tall, spreading a maximum of 30 to 36 inches; outer leaves numerous, usually 18 to 22, forming about 35 per cent of the total weight of the plant, quite spreading, only those near the head approaching an upright position, thus giving the plant an open, spreading appearance, little inward curve of leaves except those close to the head; distinctly gray-green in color; leaf surfaces nearly smooth, but slightly undulate, except the borders of the leaves which are slightly undulate or wavy; edges slightly scalloped; ribs conspicuous and a little lighter in color than other parts of

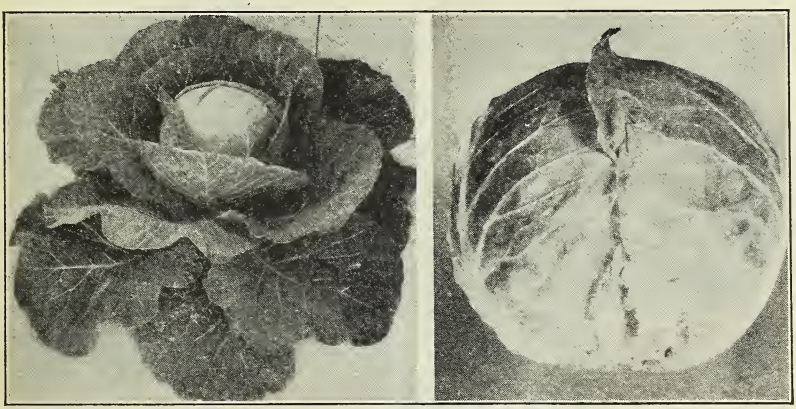

FIGURE 4.—Glory of Enkhuizen

the leaf; veins conspicuous. Head very light green in color, in moderate contrast to leaf color; large, hard, typically 5½ to 7 pounds (very large heads are objectionable for market, although suitable for sauerkraut), measuring 8½ to 9 inches in diameter and 5¾ to 6½ inches from top to base, being of the flat type, but not so distinctly flattened as the Flat Dutch; top and base broadly rounded; slightly angular in cross section on account of flattening of sides at midribs of head leaves; ribs medium in height but not conspicuous in color; veins inconspicuous; "bloom" light; interior medium compact, with very little space between the leaves; midribs arise from the stem or core usually at right angles to the core or slightly above the horizontal; core above medium size, 1½ to 1¾ inches in diameter at the center, and 3½ to 4 inches long, generally extending nearly two-thirds of the distance from the base to the top of the head.

All Seasons is a midseason variety that is grown for market or for sauerkraut.

Early Winnigstadt (fig. 6).—The name Early Winnigstadt is misleading, because it is not an early variety, but is an early midseason variety that reaches harvest 85 to 90 days after being transplanted in the spring.

Plant very large, 14 to 16 inches tall, spreading 32 to 36 inches; distinct and characteristic in appearance because of the widely spreading leaves which are somewhat elongated and have wavy or coarsely frilled margins; outer leaves medium in number, usually 14 to 16, very large, forming about half of the total weight of the plant; leaves very slightly curved except those clasping the head, outermost having very distinct petioles or leafstalks; ribs and veins prominent in height and lighter in color than other parts of

the leaf; "bloom" or waxy covering very heavy, giving the plants a distinctly grayish color. Stem tall and very large, with numerous large buds or miniature heads where the outer leaves are attached to the stem (more pronounced than in other varieties). Head small to medium in size, typically 2¾ to 3¼ pounds and constituting only about 35 to 40 per cent of the total plant weight

FIGURE 5.—All Seasons

(less than in other commercial varieties), measuring 7 to 8 inches long, and 5¼ to 5¾ inches in diameter, distinctly pointed, the base sharply rounded, and the cross section slightly elliptical or very slightly compressed; point well filled and hard, and the other parts very hard; outer head leaves extend about two-thirds around the head, an unusual distance, and are held tightly

against the leaves beneath; outermost head leaves extend slightly above the point of the head and curve outward forming a characteristic leafy tuft or tip; interior is unusually compact, with practically no spaces between the leaves; midribs arise from the stem or core at an angle of about 60° (more nearly erect than in other varieties); core thick and short, distinctly conic in shape, 1½ to 2 inches in diameter and 2½ to 3 inches long.

It is grown mainly for late-fall and winter shipping in the mild regions of the Pacific Coast States. Early Winnigstadt will stand in the field longer after becoming firm, without bursting, than other commercial varieties.

Late Flat Dutch (fig. 7).—Late Flat Dutch is a medium-late variety; it reaches harvest in about 95 to 105 days.

Plant very large, 12 to 14 inches tall, spreading 32 to 36 inches, appearing flattened or distinctly spreading; outer leaves broad, nearly flat, numerous, typically 18 to 20, constituting about a third of the total weight of the plant, having distinct petioles or leafstalks and standing a little above horizontal, curving slightly upward and inward across the blade; inner leaves stand nearly erect and are arranged close together, giving an appearance of denseness or leafiness; ribs prominent in height, moderately conspicuous in color; veins not prominent in height and markedly light in color; "bloom" or waxy covering

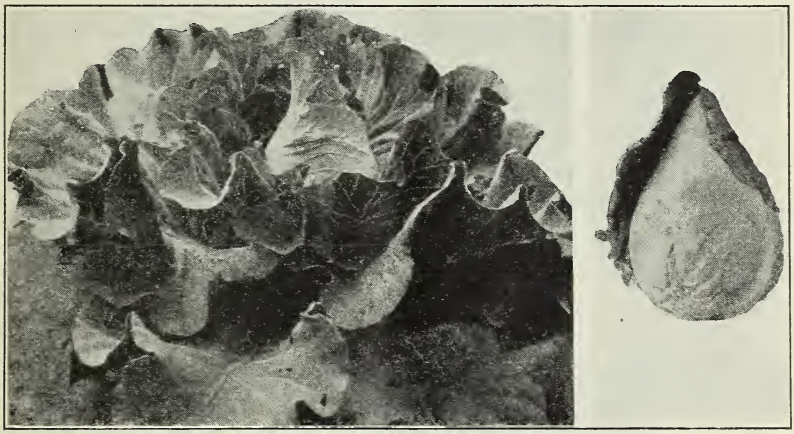

FIGURE 6.—Early Winnigstadt

medium heavy, giving a gray-green appearance. Head very large, typically 7 to 8 pounds (although much larger heads can be grown), measuring 9½ to 11 inches in diameter and 6 to 6½ inches from top to base, being distinctly flattened, in cross section it is round; top and base hard; outer head leaves reach the center of the head and are rather loosely held; ribs medium in height and inconspicuously lighter in color than other parts of leaves; veins small and dark in color; head interior medium compact, with inner leaves crumpled; midribs usually slope downward from the core or stem for a short distance, then curve sharply upward and over; core medium large, about 1½ inches in diameter and 3 to 4 inches long, extending two-thirds of the length of the head.

It is grown to a limited extent for late local markets, but chiefly for late shipping and for sauerkraut.

Danish Ballhead (fig. 8).—Danish Ballhead reaches harvest usually in 105 to 115 days, but may require 120 days in cooler regions.

Plant large, 13 to 15 inches tall, spreading 30 to 34 inches; stem taller than in most varieties; outer leaves many, typically 20 to 22, large and broadly rounded at tips; outermost leaves horizontal or drooping, mostly standing well away from the head, and the next inner leaves curving broadly upward with the tips curving slightly outward, giving the plant an open or loose rosette appearance; outer leaves nearest the head lie close to the head from its base to middle, then bend sharply away; leaves nearly smooth but broadly curved; borders very slightly wavy and edges just perceptibly scalloped; ribs medium in height and conspicuous in color; veins inconspicuous and dark in color; "bloom" or waxy covering heavy, giving a silver-green color. Head

medium large, typically 5 to 6 pounds (heavy for its apparent size and not globular as the name implies), measuring 7 to 8 inches in diameter and 6 to 7 inches from top to bottom, diameter being about one to one and one-fourth times the depth; broadly rounded to slightly flattened over top and somewhat elongated toward base; top and base very hard and interior very compact; outer head leaves reach barely past the center and are held tightly; "bloom" medium; directions of midribs arising from the stem or core are

FIGURE 7.—Late Flat Dutch

characteristic, those near the base at an angle of about 30°, those in the middle horizontal; core rather large, 1½ to 2 inches in diameter and 3½ to 4 inches long, reaching two-thirds of the length of the head.

Danish Ballhead is a late variety grown to a limited extent for late local marketing, but chiefly for late shipping and storage.

Wisconsin Hollander.—Wisconsin Hollander is somewhat similar to Danish Ballhead and is grown for the same purpose. (See Danish Ballhead.) Its main distinction from Danish Ballhead is its resistance to cabbage yellows, a serious disease. It is a few days later, is coarser in appearance, and even the

better stocks are more variable than the better stocks of Danish Ballhead. It is rarely grown except on yellows-infested soils.

Wisconsin Hollander is late, reaching harvest in 110 to 120 days. Plant very large, coarse, and tall, 14 to 16 inches in height, spreading 36 to 40 inches; stem taller than in other varieties, with base of head often 6 to 7 inches above the soil; outer leaves numerous, typically 20 to 22; outermost leaves droop downward from the tall stem, then curve upward slightly toward the ends; leaves very large and coarse, the surfaces slightly crumpled, borders somewhat wavy, and the edges distinctly scalloped, lacking the neat, trim appearance of most varieties; "bloom" or waxy covering heavy, giving a silver-green appearance.

Wisconsin All Seasons.—Wisconsin All Seasons was developed from All Seasons, which it resembles in type, except that it matures a little later. It is a drumhead variety and is used widely for sauerkraut manufacture in yellows-infested areas as it is resistant to yellows.

All Head Select.—All Head Select is a flathead type selected from All Head Early. It is a midseason variety and matures about 10 days earlier than Wisconsin All Seasons and is resistant to yellows.

Marion Market.—Marion Market is a midseason round-head variety selected from Copenhagen Market. It matures in about the same season as All Head Select and is thus somewhat later than the earliest strains of Copenhagen Market. It was developed for resistance to yellows.

Globe.—Globe is a midseason round-head variety selected from Glory of Enkhuizen. It matures slightly later than Marion Market and is disease resistant.

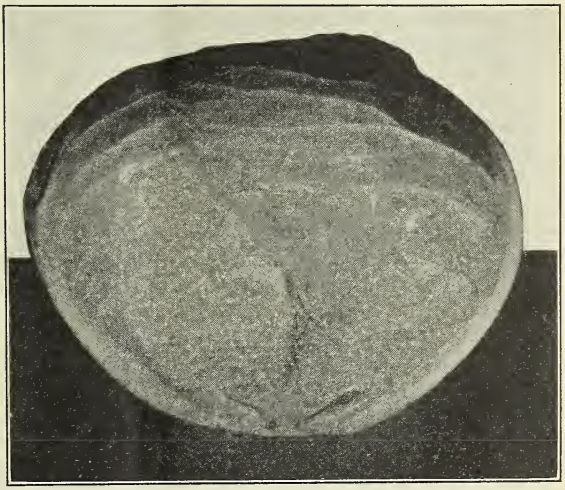

FIGURE 8.—Danish Ballhead

IMPORTANCE OF GOOD SEED

Most cabbage growers have been disappointed at one time or another by the presence of a large proportion of mixtures or off-type plants in their fields. Plants that fail to head, although conditions are proper for good head formation, heads of undesirable shape, or heads that reach harvest stage too early or too late, are all serious losses. Probably the seed stocks of no other vegetable crop are more subject to criticism because of lack of uniformity and the presence of undesirable types.

On account of the complexity of the hereditary make-up of the cabbage plant, much careful work and considerable expense are required to obtain a stock that is uniform and of good type. Furthermore, once a good stock or strain is obtained, it may easily become mixed and off type because cabbage belongs to a species of plants that is commonly cross-fertilized, that is, the flowers of one plant are fertilized by the pollen from other plants of the same species. If different varieties of cabbage are flowering near one another, they will cross and plants grown from the seed of such crosses will be a

mixture of types quite lacking in uniformity. As cabbage will also cross readily with cauliflower, broccoli, Brussels sprouts, collards, and kale, which belong to the same species, it must be carefully isolated from such plants when grown for seed. Thus, carelessly grown or carelessly handled stock is very liable to be badly mixed and off type.

In efforts to lower the cost of production, cabbage growers may attempt to save money by purchasing seed at the lowest possible price. In turn, some seedsmen in their attempts to supply the demand for low-priced seed and to meet the prices of competitors are forced to offer some poor stocks. Seed sold at a high price is not always good, but it should be evident that really good, uniform, true stocks that have been carefully and properly produced can not be sold profitably at the lowest prices. Growers must realize that the production of good seed is more costly than that of poor seed, that the grower of good seed deserves a fair profit on his product, and that the best seed available is really the cheapest even though the price be twice that of inferior stock.

The surest method of obtaining good seed is to deal with seedsmen with established reputations for handling good stocks who make no extravagant claims concerning their seeds. Other growers may be consulted as to the satisfaction rendered by specific firms. One should adhere to the well-established and well-known varieties for commercial plantings, trying new introductions only on a small experimental scale until their suitability and value are known.

LIME

Although fertilizer practices vary quite widely in different regions, and may even be different for a spring crop and for a late crop in the same region, strikingly similar results have been obtained all over the country with reference to the beneficial effects of lime applied to very acid soils upon which cabbage is grown. Cabbage is not injured by a slight degree of acidity; therefore lime will be of little if any benefit on only slightly acid soils. Furthermore, if a soil is only slightly acid, there may be danger of applying too much lime unless the acidity is definitely known and the application of lime carefully controlled. An excess of lime is often more serious than a deficiency. One must not guess at lime requirements and lime applications. Even if no damage is done to a crop by improper use of lime, it may be a waste of labor and money.

The results obtained in a 5-year rotation experiment [4] conducted by the Bureau of Plant Industry on the muck soil of the Kankakee Valley, near South Bend, Ind., furnish striking proof that lime is practically without beneficial effect on organic soils that are only slightly acid. In this experiment the average yield of the unlimed plots was 9.40 tons per acre, and that of the plots receiving 1 ton of ground limestone per acre was 9.64 tons per acre. The very small increase in yield from the limed area did not pay for the lime. The results were not affected by clubroot, as this disease was not present.

[4] Unpublished.

In experiments in New Jersey, Blair and Prince (*5*) applied a ton of calcium limestone per acre to a sassafras loam soil at 5-year intervals and a 5-year rotation of vegetable crops was grown for 20 years. The unlimed soil in these experiments remained very strongly acid and produced only 9 tons of cabbage per acre, whereas the soil receiving a ton of limestone every 5 years was rated as only moderately acid, and produced 18½ tons of cabbage. Two adjacent areas were given one-half ton and 2 tons of limestone, respectively, instead of 1 ton. The ½-ton treatment partly corrected the acidity leaving the soil still strongly acid. However, over 15 tons of cabbage were produced. The 2-ton treatment completely corrected the acidity, but the yield was less than on the moderately acid soil. Most crops do better on a soil just slightly acid than on one which is neutral or alkaline, other things being the same.

Many years ago Harter (*16*), at the Virginia Truck Experiment Station, showed that 1,200 to 2,000 pounds of lime applied to a strongly acid soil during preparation before transplanting gave very substantial increases in yield that same year. Experiments upon early cabbage in Ohio, Comin and Bushnell (*11*) and Gourley and Magruder (*15*) over a period of 12 years, showed that 1 ton of limestone gave an average annual increased yield of over 1½ tons, with a net value of about $75 per acre per year. The soil used in these experiments was a loam to fine sandy loam. Before the application of lime it was rather strongly acid, the treatment reducing the acidity to a point considered only moderately acid.

These few experiments show the value of moderate amounts of lime when applied to strongly acid or very strongly acid soils. Presumably the benefits here cited are derived from improved growth of the crop entirely aside from the control of the clubroot disease. No reference to its presence was made. If the disease had been present in the strongly acid soils, the benefits from lime would have been still greater. The effect of lime upon clubroot is discussed later in this circular in the section on diseases.

Growers can obtain determinations of the lime requirement of their soils through their county agricultural agent or through their State experiment station. These agencies will furnish instructions for taking soil samples and for applying the lime. The lime should preferably be applied in the fall or winter preceding the cabbage, but may be applied in the spring before the cabbage is transplanted.

ORGANIC MATTER

Although it is generally recognized by vegetable growers that a plentiful supply of organic matter in the soil is essential to the best results, a few examples of what actually has been obtained with cabbage will emphasize the value of organic matter in growing this crop.

At the Virginia Truck Experiment Station Harter (*16*) found that plowing under green cowpeas in the fall before frost gave increases in yield of cabbage the following spring of 150 and 200 per cent in two different tests. These results were obtained on soil very low in organic matter which produced very low yields of cabbage on the areas without green manure, even though 3,000 pounds of

commercial fertilizer had been added. If the cost of fertilizer is estimated at $40 per ton and the price of cabbage at only 75 cents per barrel, the increased value of the crop due to plowing under organic matter was about $40 per acre in the first test and $75 in the second.

On mineral soils the effect of manure as a source of organic matter, as well as of fertilizing elements, is unquestioned. Experimental results and practical experience on these soils the country over have shown that good yields of cabbage can be obtained by applying 20 to 30 tons of manure per acre per year, especially if this be supplemented by commercial fertilizers. With peat soils, which are extensively used for cabbage growing, the situation may be quite different.

The rotation experiment on the muck soil of the Kankakee Valley in northern Indiana referred to on page 16 showed that while an application of 15 tons per acre of manure gave an average increase in yield of 2.5 tons per acre, this increase was less than that obtained from an application of 200 pounds per acre of muriate of potash. The value of the cabbage in the field was about $6 per ton, or a total increase in the value of the crop of $15 due to the manure. This allowed only $1 per ton for the manure and the cost of its application. Under such circumstances manure could be more profitably used on mineral soil.

With the recent scarcity and high price of manure it can not often be used profitably as the sole source of organic matter. To what extent, then, can green manures replace animal manures? Hartwell and Damon (*17*), in Rhode Island, working on silt-loam soil, showed that by turning under a green-manure crop each fall and using 2,200 pounds of a complete fertilizer higher yields of cabbage could be maintained over a period of years than by applying annually about 30 tons of manure alone. Slightly better yields were obtained where 8 tons of manure were used in addition to the green-manure crop and fertilizer. It appears, however, that the quick-growing green-manure crops grown each year were approximately as effective as 10 to 15 tons of manure. Cabbage can be grown without animal manures, but yields can not be maintained without some form of organic matter.

The choice of a green-manure crop will depend upon the time available for growing it and upon the weather and soil conditions where it is to be grown. A simple rule is to grow that crop as a green-manure crop that will produce the greatest amount of material in the time available. In the more northern States buckwheat, rye, and oats are much used, while to the south crops that require warmer weather, such as cowpeas or soybeans, may be used. When there is sufficient time a legume crop is preferred, because leguminous plants, if inoculated with certain bacteria, can obtain nitrogen from the air, thereby increasing the soil nitrogen when the crop is plowed under. However, a nonlegume is certainly better than no green-manure crop at all.

A few precautions in handling green-manure crops are very important. The crop should be plowed under before it is killed by cold if it is nonhardy. Dead remains of a crop that have been exposed to weathering are of less value than if the crop is plowed under in the green state. Harter (*16*), in Virginia, found in two tests that cowpeas, turned under dry in midwinter, were only 65

and 70 per cent as effective in increasing cabbage yields the next spring as when they were plowed down green before frost.

A green-manure crop should be turned under before the plants mature and become hard and woody, or tough. Plowing under large quantities of woody or strawy material usually causes a temporary depression in yield of the crops which follow. This happens because the decay of the tough, woody, or strawy material is brought about by microorganisms in the soil which require large quantities of readily available nitrogen in order to carry on their work. The more old, tough, woody material turned under, the more slowly will it be decayed and the more serious will be the temporary shortage of available nitrogen in the soil. If the plowing down of a green manure is unavoidably delayed until it reaches this undesirable stage, applying 150 to 200 pounds of nitrate of soda per acre will hasten decay and lessen later trouble. Under such circumstances heavier fertilizing of cabbage in the spring with readily available nitrogen is advisable.

The development and maintenance of a good organic-matter content of the soil will do much to reduce the difficulties of drought, leaching, soil acidity, and often other unfavorable soil conditions that are not well understood.

CROP ROTATION

In order to help hold insects and diseases in check, cabbage should be grown on the same land not oftener than once in three or four years and preferably at longer periods. It is difficult to plan a four or five year rotation in the highly specialized trucking areas where comparatively few crops are grown on a large scale, but the rotation should be as long as practicable.

In the Middle Atlantic cabbage regions the following rotations, or similar ones, are practicable:

Example A

First year.—Cabbage followed by green manure, followed by fall-planted spinach for winter or early-spring harvest.
Second year.—Corn followed by green manure.
Third year.—Cucumbers, beets, or squash, followed by fall spinach or beans.
Fourth year.—Beans followed by green manure.

Example B

First year.—Cabbage followed by green manure, followed by fall spinach.
Second year.—Potatoes followed by corn, followed by green manure.
Third year.—Sweetpotatoes followed by green manure.
Fourth year.—Beans, peas, or cucumbers, followed by green manure.

In the Gulf States, in which spinach is not commonly grown, root crops such as carrots, beets, or turnips, or other short, cool season vegetables may be substituted. In general, no specific rotations are followed, since the crops and acreage to be grown depend so much on the current and immediately prospective market conditions. However, an effort is made by the better growers to grow cabbage (or kale or broccoli) on a certain field only once in three or four years. A common series of crops for a single season is: Early potatoes, corn and soybeans, fall or winter cabbage.

In the northern late-cabbage regions the crop is grown more as a staple farm crop than as a market or truck crop and has a more definite place in a rotation. It is also grown extensively along with canning crops, as:

EXAMPLE C

First year.—Cabbage.
Second year.—Sweet corn.
Third year.—Peas followed by red clover.
Fourth year.—Clover.

EXAMPLE D

First year.—Cabbage.
Second year.—Sweet corn.
Third year.—Peas followed by white sweetclover.
Fourth year.—Tomatoes.

A suggested rotation for northern muck lands:

EXAMPLE E

First year.—Sod or mint (may remain for two or more years).
Second year.—Corn with soybeans, or potatoes.
Third year.—Onions or lettuce.
Fourth year.—Cabbage.

In some of the irrigated regions of the West cabbage is grown in rotation with melons, sugar beets, potatoes, and alfalfa.

Cabbage is a comparatively short-season crop, not particularly difficult to handle, is a gross feeder, and so will fit into a wide variety of cropping systems.

SOIL PREPARATION, CULTIVATION, AND WEED CONTROL

A grower hardly needs to be convinced of the great value of deep, careful plowing and thorough preparation of the soil before transplanting cabbage. It is common knowledge that a deep, firm but friable soil that is free from clods and trash gives a better stand of plants and results in more extensive root development and better early growth than a poorly prepared soil. The matter of cultivation after the plants are established is not so clear.

Extensive studies of the root system of cabbage and of the effect of different systems of cultivation upon root and top growth have been made by Thompson (*24*) in New York and also by Weaver and Bruner (*28*) in Nebraska. The results of the work in these widely separated parts of the country agree remarkably well, indicating that the results are generally applicable.

Even when the top of a young cabbage plant is only 5 to 6 inches tall and 8 to 10 inches across, large numbers of roots extend laterally to the middle between the rows and others penetrate to a depth of 2 to 2½ feet. At this time most of the roots are in the upper 12 inches of soil, and many roots are within 2 to 3 inches of the surface. It is obvious that cultivating more than 3 inches deep close to the plants may destroy many roots.

By the time the plants are half grown, roots entirely fill the space between the rows. In the Nebraska studies, where the plants were grown in deep, mellow, silt-loam soil, few roots of such plants were nearer the surface than 6 inches, and ordinary cultivation to a depth

of about 3 inches would therefore do no appreciable harm. On the other hand, in the New York studies where the plants were grown in a gravelly loam containing considerable clay, an appreciable number of roots lay very close to the surface and would have been destroyed by cultivation. The roots of nearly grown plants were found to be very numerous near the surface of the soil even though most of the root system lay between depths of 6 inches and 2 feet.

When cabbage plants are cultivated in the ordinary way there is no danger of root injury in cultivating as deep as 3 inches, close to the plants, while they are still small. After the plants are half grown, cultivating 3 inches deep will cut off many roots unless the soil has been frequently stirred to that depth, thereby preventing root growth near the surface. In the Nebraska studies, scraping the soil to a depth of only one-half inch resulted in better growth than cultivation 3½ inches deep. Deep cultivation prevented root development in the surface 3 inches of soil that makes up a large proportion of the rich topsoil. In the New York experiments (*24*, *25*) shallow cultivation with a hand cultivator and scraping the soil surface with a hoe gave practically the same results.

Deep cultivation (more than 3 inches) during relatively dry weather may result in greater loss of water from the soil during dry weather than does shallow cultivation (1 to 2 inches). The latter is doubtless preferable to scraping on soils which bake very hard, since the loosened and irregular surface will absorb more rainfall.

The experiments here described prove that the main benefit derived from cultivating cabbage is the control of weeds. Weeds must be kept down because they use much of the soil moisture and fertility that are needed by the crop plants. Shallow cultivation often enough to destroy the weeds is all that is necessary. Fairly deep cultivation is necessary in working in top dressings of complete fertilizer early in the spring but is likely to be very injurious to the roots later in the season. There is no advantage in cultivating oftener than is necessary to work in fertilizer and to control the weeds.

COMMERCIALLY GROWN PLANTS FOR TRANSPLANTING

Within recent years the large-scale commercial production of cabbage and other vegetable plants for transplanting has assumed considerable importance. Plants grown in the South may be shipped hundreds of miles to those who will grow the crop to maturity. (Fig. 9.) Although the purchase and shipment of such plants may be entirely satisfactory, there are hazards which require special attention if trouble is to be avoided.

As much care should be exercised in choosing a source of plants as in choosing a source of seed. Good plant growers take pride in handling only stocks that are of uniform type, true to name, well grown, well packed for shipment, and delivered at the proper time.

Although for the most part the purchase and shipment of such plants is entirely satisfactory, at times it has its disadvantages. Shipments may be delivered during a period of bad weather, making it necessary to hold the plants a few days before they can be trans-

planted. In such an event the packages of plants should be opened and carefully examined. Any heating of the plants is very injurious and must be prevented by unpacking so that all plants will have free access to the air. If wilting, drying of roots, or yellowing of leaves has started, or if the plants must be held more than a day or two before being planted, they should be "heeled in" in moist soil. Each bunch of plants should be opened and the plants spread out so that the tops have free access to air and light, and the roots are in contact with the moist soil.

Losses sometimes occur in transit. It is not often possible for the purchaser to have accurate knowledge beforehand about the plants he is to buy, and as a result he may be disappointed in their size or

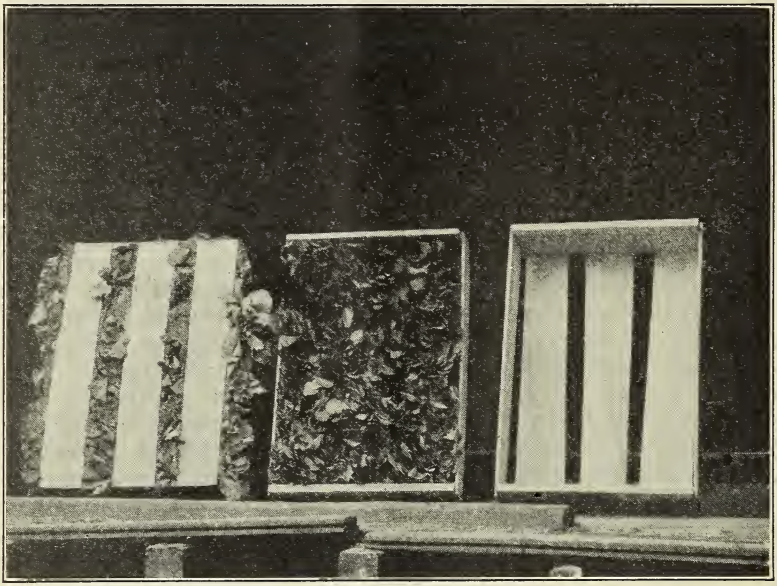

FIGURE 9.—Shipping container for southern-grown cabbage plants

apparent vigor when they are received. Unless plants shipped North are well hardened, severe losses from cold may result. Certain diseases may be introduced upon shipped plants unless the producer has taken precautions to keep them disease free. These dangers and difficulties are mentioned here, not to discourage the practice of buying and shipping plants from a distance, but only so that all possible steps may be taken to insure satisfaction. Many growers prefer to buy plants instead of raising them and are well pleased with the results obtained.

The so-called "frost-proof" cabbage plants that are frequently advertised are plants of the common varieties that have been slowly hardened and subjected to such low temperatures that they will be uninjured by moderate freezing. This resistance to cold is not permanent. If a temporary period of warm weather occurs, the plants lose their hardiness, as described on page 40. After vigorous growth has started, the plants are as susceptible to cold as any other plants of the same variety.

TRANSPLANTING TO THE FIELD

Hand setting in the field is very widely practiced. In the South and West, where the plants are grown on ridges or on the sides of furrows, machine planters can not be used satisfactorily. In nonirrigated regions the plants must be firmly set and the soil tightly pressed against the roots; in irrigated regions the plants are merely dropped into the hole made with the dibble, the soil falling about the roots of the plant as the operation is completed. The soil is then settled about the plants by running water to the desired level in the furrows. By this simple procedure an expert plant setter can "stick" about 20,000 plants a day if they are dropped for him at the proper intervals by another worker. In nonirrigated regions where the operation is not so simple, the setting of 6,000 to 8,000 plants is a day's work for a pair of workers.

Horse-drawn machine transplanters which supply water to the roots of the plants as they are set are advantageous on soils in the North which are sufficiently level and well prepared to permit their use. Hand setting is also very common, however, because many growers prefer to mark off the rows both ways and plant in check rows so that the field can be cultivated both ways, largely eliminating hand hoeing and hand weeding.

Some growers report good results with a small hand-machine transplanter which supplies water as the plant is set.

Plants must be set so that moist soil is placed in firm contact with the roots. The plants should be set a little deeper than they stood in the plant bed, so that the "bud" or "crown" of the plant is just high enough above the soil that there is no danger of its being covered. Plants set out in the fall in regions where alternate severe freezing and thawing occur must be set especially firm and fairly deep to avoid being heaved out of the soil.

CABBAGE CULTURE IN THE SOUTH

REGIONS AND VARIETIES

Cabbage is grown in the South primarily for early shipment to northern markets. The more important regions of production for earliest shipment are in California, Florida, South Carolina, Louisiana, and Texas. Shipments then follow from Alabama, North Carolina, Mississippi, Virginia, Tennessee, and Maryland. In Florida, the Carolinas, Mississippi, and Virginia, the Early Jersey Wakefield and Charleston Wakefield varieties are grown almost exclusively. Copenhagen Market is most popular in Louisiana and Tennessee; it is extensively grown in Alabama and Texas, but other varieties such as Early Flat Dutch are also important. In California Early Winnigstadt is the leading variety for early shipment.

GROWING PLANTS FOR TRANSPLANTING

In most of the Southern States, cabbage plants are usually started in beds in the open. It is not possible here to recommend specific dates for the sowing of seed because suitable dates vary widely in different regions and even in different localities not far distant from

each other within a general region or State. First-hand experience or at least observation is necessary in determining this very important point. In sowing cabbage in open beds in the fall or winter one must bear in mind the important effects of temperature upon the growth and development of the plants previously discussed.

As is emphasized in the section on diseases, it is important to select an area for a plant bed upon which no cabbage, cauliflower, kale, broccoli, or related plants have been grown recently. A wide variety of soil types is suitable for plant growing, but the soil should be reasonably mellow, one which does not form a hard crust that would prevent or delay the emergence of the seedlings. A soil that packs hard causes too many roots to be broken from the plants as they are pulled for transplanting; a loose, friable soil, therefore, should be used if possible. An extremely open sandy soil, however, is not best because it tends to become very dry. If the surface soil dries out even for a few days such a delay of germination may result that the young plants will be so small as to winterkill severely, or at least be undesirably small at transplanting time.

If it is necessary to apply fertilizer to the plant bed this should be done several days before the seed is sown. The fertilizer should be broadcast after plowing and thoroughly disked or harrowed into the surface 2 or 3 inches of soil. Cabbage seed is especially susceptible to injury by fertilizer. Failure to thoroughly mix the fertilizer into the soil in advance of sowing is practically certain to delay germination, and only a 20 to 50 per cent stand may result or the seeds may be killed.

Growers are further cautioned against the use of too rich soil or too much fertilizer in the plant bed. Plants that are forced in growth by excessive fertilizing are usually weak, spindling, soft, and quite unsuitable for transplanting. Studies by Boswell (*6*) in Maryland showed that many more of the plants fertilized with nitrate of soda were winterkilled than of the plants of the same size that had been fertilized with superphosphate or that had been untreated. A moderate rate of growth on moderately fertile soil should be sought.

In addition to the danger of winterkilling heavily fertilized plants, there is the danger of their becoming so large that they may go to seed. The size of plants should be kept down so that the stem diameter at the thickest place is no greater than that of a lead pencil at the time the plants are to be subjected to cold weather. The grower should have an abundance of plants available so that undersized and oversized plants can be discarded and only the best set in the field.

Seed may be broadcast and lightly covered about one-fourth to one-half inch deep by raking but preferably should be drilled thinly in rows 12 to 16 inches apart. A pound of seed should produce 20,000 plants, which are ample for transplanting 2 acres. A pound of seed so planted will require about 2,500 square feet of bed. On a large scale, seed should be sown at the rate of about 15 pounds per acre of plant bed.

In certain sections of the South, particularly eastern Virginia and eastern North Carolina, seed for a late fall or early winter crop of cabbage is sown in place in the field. The seed is planted in July or

August at the rate of 2 pounds per acre, and the plants are later thinned to a stand. High temperatures in these regions make transplanting generally unsuccessful, thus necessitating the sowing of the seed in the place where the plants are to grow until harvest.

SOILS

Early cabbage is grown upon different soil types ranging from sandy loams in Virginia, the Carolinas, and Florida to loam soils in Louisiana, Mississippi, and Texas. Sandy soils are also used to a limited extent in these latter States. Other things being the same, the lighter soils are preferred for an early crop because they are less retentive of moisture and are warmer than heavy soils in mild winter weather and in the spring. They also can be worked to better advantage than heavy soils.

PREPARATION FOR TRANSPLANTING

The manner of preparing the soil for transplanting cabbage varies greatly in different locations and depends upon the kind of soil, the slope of the land, temperature, and rainfall. In Maryland, Virginia, and the Carolinas, ridges are generally thrown up 3 feet apart and 10 to 12 inches high a week or two before transplanting time, and the soil is allowed to become firm and settled. The ridges usually lie approximately east and west, and the plants are set 12 to 15 inches apart about halfway up the south side of the ridge where they are protected somewhat from the northerly winds and get the maximum warmth from the sun. In parts of Louisiana and Alabama, the plants are set on top of ridges that are 4 feet apart and 12 to 15 inches high, in order to keep the plants above the water-logged soil and facilitate drainage. Large areas of good cabbage land are so nearly level and the rainfall is so heavy that the use of such ridges is essential. In irrigated districts the plants are grown on the sides of ridges in order that water may be supplied through the furrows between them. Planting intervals in the row are essentially the same the country over—about 12 to 15 inches for small varieties and 15 to 18 inches for medium-sized varieties.

MANURE

The value of manure as a source of organic matter has already been discussed (p. 18). The use of manure as a source of fertilizing elements is a much older practice than the use of commercial fertilizers. Animal manures are satisfactory as sources of the fertilizing elements, nitrogen, phosphorus, and potassium, but these constituents can also be obtained in satisfactory form in commercial fertilizers. On account of the high price and scarcity of manure in most locations, few growers can afford to use it. If it can be obtained near by for little more than the cost of hauling it to the field and applying it, annual applications of 20 to 30 tons per acre with no commercial fertilizer may give fair yields on the naturally fertile soils in warm regions. However, large quantities of manure alone have not proved to be as profitable as smaller amounts of manure plus commercial fertilizer. In the southern cabbage regions green manures and com-

mercial fertilizers must be depended upon for the most part, as very little manure is available.

Although not strictly applicable, experimental results obtained in the more northern parts of the country should offer valuable guidance. Experiments conducted by the agricultural experiment stations of Rhode Island (*17*), Ohio (*11*, *15*), Maryland (*29*), and Pennsylvania (*20*) all show that 4 or 5 tons of manure per acre, plus commercial fertilizer, is much more profitable than large applications of manure alone (20 to 30 tons per acre). Green manures and plenty of commercial fertilizer must be used if animal manures are not available. Kinds and amounts of fertilizer are recommended in the following section.

COMMERCIAL FERTILIZERS

In the following discussion of commercial fertilizers it is to be understood that they are to be used in addition to green-manure crops or moderate amounts of manure that are turned under to maintain organic matter. The best results with any amount of commercial fertilizer can not be obtained on soils seriously deficient in organic matter or on those that are strongly acid. As stated previously, strong acidity should be corrected by lime.

Cabbage is usually grown in the South during the winter or early spring, when the weather during most of the growth period is relatively cool. Fertilizing materials, such as cottonseed meal, tankage, fish scrap, and manure, which are applied chiefly for their nitrogen, contain this element in a complex form which can not be taken up by the plants. The nitrogen of these materials becomes available only after a certain series of decompositions occurs in the soil, changing the complex nitrogen into the nitrate form. These changes require considerable time and are greatly influenced by the temperature and also by the amount of water and air in the soil. Nitrates are produced very slowly, if at all, when the soil is cold and waterlogged in the winter or early spring, but more rapidly as the soil warms up and is better drained. Because the cabbage plant is able to grow so early in the spring and at such cool temperatures, unless readily available nitrogen is artificially supplied, very little nitrate will be present in the soil and the plant may suffer for lack of it.

The nitrogen in nitrate of soda is immediately available for growth of the plant, so this fertilizer is of especial value in promoting growth early in the season. It should not be the only source of nitrogen, however, because it is so soluble that it may be leached out by rain and therefore lost before the plant has absorbed it. The nitrogen in sulphate of ammonia is changed into nitrates much more quickly than the nitrogen in organic materials, such as cottonseed meal and tankage; furthermore, sulphate of ammonia does not leach from the soil like nitrate of soda. As the soil warms up, the sulphate of ammonia is changed into nitrates and used by the plants. The organic forms of nitrogen are changed into nitrates more slowly than sulphate of ammonia, becoming available to the plants only after some weeks of relatively warm weather.

Thus it would seem that a mixture of nitrate of soda, sulphate of ammonia, and some such material as tankage, would afford a fairly steady supply of available nitrogen through the most of the time

of the growth of the crop. Experiments have shown this to be true. On sandy types of soil where considerable leaching occurs, the Virginia Truck Experiment Station recommends (*31*) about a ton per acre of the following mixture: 324 pounds of nitrate of soda, 240 pounds of sulphate of ammonia, 600 pounds of high-grade animal tankage, 636 pounds of superphosphate (16 per cent P_2O_5), and 200 pounds of muriate of potash. This mixture analyzes approximately 7½ per cent nitrogen (or 9 per cent ammonia), 6 per cent phosphoric acid, and 5 per cent potash.

Upon heavier soils, which are not so subject to leaching and which warm up a little more slowly, a larger proportion of the nitrogen should be in the more readily available forms. The Virginia Truck Experiment Station (*31*) recommends for such soils the following mixture: 486 pounds of nitrate of soda, 360 pounds of sulphate of ammonia, 750 pounds of superphosphate (16 per cent P_2O_5), 200 pounds of muriate of potash, and 204 pounds of filler or conditioner. This mixture analyzes the same as the above, but more of the nitrogen is readily available.

Ware, in Mississippi (*27*) has published results of cabbage-fertilizer tests on Ocklocknee loam soil. Of the many different treatments studied the application of 2,000 pounds of a 4–10–4 fertilizer with the nitrogen in readily available form, as nitrate of soda and sulphate of ammonia, gave the largest and most profitable yields.

In Maryland it is a common practice to use a 7–6–5 fertilizer on early cabbage, the nitrogen being derived from nitrate of soda and sulphate of ammonia.

A very interesting and important point is indicated in these experiments. When sulphate of ammonia was used as the only source of nitrogen in the fertilizer slightly better yields and firmer heads were obtained than when nitrate of soda was the only source of nitrogen; when a combination of the two was used, half and half, the results were still better.

The time and manner of applying the fertilizer to overwintered cabbage is important. Carefully controlled experiments conducted by the Michigan Agricultural Experiment Station by Edmond and Lewis (*13*) showed very strikingly that a uniform and constant supply of available fertilizing materials must be present through the entire growing period if the best yields are to be obtained. This is especially true with respect to earliness or heavy yields in the first cuttings. A deficiency in plant food that results in a check in growth at any time after transplanting reduces the total yield somewhat and the early yield very greatly.

In regions of light sandy soils where the crop normally makes some growth through the winter and where rapid growth starts very early in the spring, a light application of fertilizer should be made in the fall before transplanting. For such an application the Virginia Truck Experiment Station (*31*) recommends 500 pounds per acre of a mixture of 800 pounds of tankage or fish, 1,000 pounds of superphosphate, and 200 pounds of muriate of potash. Readily available nitrogen might force too much growth during brief warm periods in the winter, with resultant later cold injury and possibly an increased percentage of seeders in the spring.

It is further recommended that just before growth starts in the spring one-half of the spring application be applied to the south side of the row and immediately cultivated in. (Fig. 10.) The remainder of this complete fertilizer should be put on the north side of the row and cultivated in when the ridges are worked down level, usually two to three weeks after the first application.

In addition to the major treatment with complete fertilizer, most growers put on one or two top-dressings of 150 to 200 pounds per acre of nitrate of soda before the plants begin to head. These top-dressings may or may not be used, depending upon how well the crop is growing. During protracted periods of cool weather or after excessive rainfall the supply of readily available nitrogen in the soil

FIGURE 10.—Field set to cabbage, illustrating method of working in the first application of fertilizer in the spring. Note that only the south side of the ridge is cultivated.

may be diminished to such a point that growth slows down noticeably, and the plants take on a yellow color that indicates a need for available nitrogen. Experienced growers can quickly detect such a condition, and it is then that top-dressings of nitrate of soda are of much value.

In the lower South nitrate of soda is usually applied three and six weeks after transplanting, but the time may be varied to suit special cases. In the Middle Atlantic States the first nitrogen application is made early, as mentioned elsewhere, and a second may be made a month to six weeks later, but before the heads have formed. The plants are enabled to continue growth under otherwise adverse conditions, and the check in development is avoided which has been shown to be so disastrous to high early yields and which also reduces total yields.

If the plants continue to grow rapidly and uninterruptedly and maintain a strong, luxurious appearance and color, these supple-

mentary applications of nitrate of soda are unnecessary. It should be recalled that excessive quantities of nitrate of soda alone give results less favorable than a mixture of nitrate of soda and sulphate of ammonia. Top-dressings of sulphate of ammonia alone during a temporary shortage of available nitrogen in the soil will not produce results as quickly as nitrate of soda. Good judgment and some experience are necessary to get the most profitable results from supplementary fertilizing with nitrogen. Too-early or too-late applications of fertilizer will be wasteful and of little benefit to the plants. If heavy applications are made after heading is well started, the heads may be of inferior firmness.

In the Gulf States, where the winters are so mild that cabbage grows with very little interruption, the applications of fertilizer are made earlier, at such a time that it will be available during the development of the plant. On the lighter soils the first half (about 1,000 pounds) should be worked into the rows thoroughly before transplanting, and the remainder cultivated in about a month later. One-third to one-half of the nitrogen should be supplied by organic materials. On heavier soils, especially in the warmer regions where growth is relatively rapid, the entire amount of complete fertilizer may well be applied before transplanting. Temporary shortages of available soil nitrogen are corrected by applying nitrate of soda and sulphate of ammonia as described in the preceding paragraph.

Broadcast applications of fertilizer may be made with a special broadcast fertilizer or lime distributor and worked into the soil by harrowing and disking. The fertilizer attachment of an ordinary grain drill can be used successfully, and is often preferred since it permits the placing of the fertilizer at the desired depth of 3 to 4 inches below the surface. If this is followed by harrowing, the material is thoroughly mixed with the top 3 or 4 inches of soil.

For applying fertilizer along the rows or ridges, single-row distributors are generally employed, the fertilizer being applied during the preparation of the row or ridge and thoroughly mixed with the soil in completing the ridge. In all cases it should be well mixed with soil to prevent injury to the plants and to insure its being available to as large a proportion of the roots of the plants as possible. Where plenty of cheap labor is available, many growers make applications in the row by hand. This is a very laborious and under most conditions an inefficient method. More uniform distribution usually can be obtained by machine than by hand.

Top-dressing of small plants on ridges is very commonly done by hand, although there are on the market small distributors that will place the fertilizer close to the plants or wherever it is desired. After the ridges are worked down such a machine will deliver fertilizer to one side of each of two rows at a time, or along the middles between the rows. Such substantial saving in labor is possible with a good fertilizer distributor that even growers of small acreage should consider its use. It should help to lower the cost of production.

Fertilizer distributors must be thoroughly washed out soon after being used if serious rusting and corrosion are to be avoided. If they are to operate properly, the fertilizer must be free from lumps and in condition to flow with reasonable freedom.

HARVESTING AND HANDLING

Cabbage grown in the South for early shipment northward is often harvested as soon as it is large enough to be marketed, even though the heads may not have become hard and fully developed. This is true particularly early in the season when the price is high enough to compensate for the low tonnage harvested. Although the table quality of such immature cabbage is considered quite desirable as soon as it is harvested, the product does not carry as well in shipment as do firmer heads. Unless sold soon after being harvested the heads become decidedly soft from wilting and appear undesirable to the consumer. This often results in limiting the demand, thereby lowering prices. Slight immaturity or lack of firmness is not as objectionable in the Charleston Wakefield and Early Jersey Wakefield as in the round and flat varieties. But even with the pointed types mentioned, care should be taken to avoid harvesting the heads in such an immature condition that they will not stand up in shipment and on the retailer's stand. The very tips of the heads of Early Jersey Wakefield and Charleston Wakefield do not become hard, but they should be well filled, and the lower part of the head should be quite firm at harvest. A little experience or first-hand observation is necessary in order to judge accurately the best stage at which to harvest for early shipping.

The round and flat types should be harvested only after the heads have become hard. The outer-head leaves of a fully developed head usually are beginning to curl upward and back, over the top of the head. The color of these leaves, too, is distinctly lighter or more yellow-green.

A large, heavy butcher knife is the most satisfactory tool for cutting the heads from the rest of the plant. Neat, accurate cuts can be made, leaving two to four wrapper leaves adhering to the head and necessitating a minimum of later trimming when the heads are graded and packed.

Only heads of similar size should be packed together, and they should be graded to conform to United States grades for cabbage. These grades are subject to revision from time to time and so are not presented here. Copies of the standard grade specifications may be obtained free of charge by writing to the Bureau of Agricultural Economics, United States Department of Agriculture, Washington, D. C.

Shipments are made in a variety of containers, but one certain type is usually standard within a single cabbage-shipping region. Obviously, the grower must familiarize himself with the packing requirements of the markets in which he intends to sell. This information can be obtained from local growers, shippers, and buyers, or from the market reports issued by the Bureau of Agricultural Economics.

The preparations for market and marketing of cabbage are discussed fully in two publications of this department. Department Bulletin No. 1242, Marketing Cabbage (*8*), is designed more for the dealer, the shipper, or the grower-shipper who requires information on market requirements, marketing practices, and movements of shipments over the whole country. Farmers' Bulletin No. 1423, Preparation of Cabbage for Market (*18*), is primarily for the

grower, and discusses the harvesting, grading, packing, types of packages, methods of loading cars, and the Government inspection of cabbage. These can be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 15 cents and 5 cents, respectively, per copy.

CABBAGE CULTURE IN THE MIDDLE AND NORTHERN STATES

The following discussion will apply, with the exceptions noted, in those States lying north of a line which passes approximately along the northern boundaries of North Carolina, Tennessee, Arkansas, Oklahoma, New Mexico, and Arizona. The area in proximity to Chesapeake Bay, although north of this arbitrary line, has climatic features that are more typically southern. The same is true of certain parts of California. On the other hand, there are regions of high altitude in the Southern States where the climate is characteristic of the country much farther north but at lower elevation above sea level. Because of differences in temperature, length of growing season, and market demands, cabbage culture in the Northern States presents very different problems from the culture in the South, although the principles underlying successful growing are the same.

REGIONS AND VARIETIES

The most important of the northern cabbage-growing regions are in western and central New York; in the portions of Wisconsin, Ohio, and Michigan lying near the Great Lakes and of Wisconsin, Minnesota, and Iowa lying near the Mississippi River; and in north-central Colorado. However, important commercial acreages are found in many other States.

The greater portion of the crop of the Northern States is composed of midseason and late varieties, although the early varieties are extensively grown. Early Jersey Wakefield and Charleston Wakefield are grown for home use and early local markets but are relatively unimportant. Copenhagen Market is extensively grown in the Middle West and in Colorado for both market and sauerkraut. Glory of Enkhuizen is very popular as a market and sauerkraut variety in the more northern States. Danish Ballhead and Wisconsin Hollander are extensively grown for storage, and All Seasons is grown widely for sauerkraut. Only the Danish type can be successfully stored for long periods.

EARLY MARKET CROP

EFFECTS OF TRANSPLANTING

Differences of opinion exist among gardeners as to the best practices in growing plants for setting in the field. Some sow the seed in the plant beds and never move the plants until they are taken from the bed and placed in the field; others maintain that taking up the seedlings and transplanting them to flats, to other parts of the bed, or to other beds is better; a few transplant even a second time before placing the plants in the field.

Studies of transplanting cabbage by Loomis (*19*) at the agricultural experiment station of Cornell University show that in itself transplanting is not a benefit to the plant but, on the contrary, tends to stunt it somewhat. Considered from a practical field standpoint, however, the transplanting of plants in the beds before they were set in the field was without any appreciable effect upon earliness or yield. A very important fact must be borne in mind in considering these experiments and in applying the results to practical conditions. All plants, regardless of the number of times they were transplanted, had the same amount of space in which to grow. For example:

Three lots of seed were sown in ground beds and the seeds spaced far enough apart so that the plants could grow until ready for the field without crowding each other. The first of these lots of plants was not taken up until it was moved to the field. Two lots were taken up in the small seedling stage and reset at the same spacings at which all lots were originally sown. When the plants were 2½ to 3 inches high one of the lots that already had been transplanted once was taken up and reset at the same spacing a second time. Then all three lots were allowed to grow until set in the field. Even though the transplanting had a stunting effect they all made practically the same growth and yield in the field.

It is common knowledge that taking up a small plant breaks off many small roots and that after it is reset it soon develops a more bunchy root system than if the transplanting had not been done. At the same time the plant has been actually stunted in growth. These experiments, repeated with several lots of plants each year for three years, show that there is no advantage in stunting the young cabbage plant in order to get more "bunchy" roots for setting in the field.

The only reason young cabbage plants ever need to be transplanted in the beds or greenhouse before being taken to the field is to give them more space in which to grow. Seed is sown thickly as a matter of convenience, in order that the size of the seed bed need not be large, that good care may be given to the seedlings, and that there may be less loss of seedlings and a saving in the amount of seed to be sown. This thick sowing results in crowding that makes the plants spindling and stunts them far more than transplanting. Consequently they are transplanted to give each plant space in which to spread its leaves and to afford an adequate volume of soil for the roots.

In growing hotbed plants on a limited scale there is much to recommend thin sowing and leaving the plants in place. If the small plants are "pricked out" or "spotted" into other hotbeds or into coldframes it is necessary to work in the open, perhaps in unfavorable weather, with great discomfort to the workmen, a loss of efficiency, and also with some hazard to the plants. The weather may even be so severe as to prevent "spotting" being done at the proper time, and result in a loss of seedlings or the production of inferior plants for setting in the field. Sowing about three-eighths ounce of seed per sash in rows from 4 to 4½ inches apart, followed by some thinning out of the weaker plants, should leave 1,000 to 1,100 good, strong plants per sash. This is approximately the number that

would be spotted in the same area at 1½ by 1½ inches, and the plants can be grown with less expense and less hazard of loss or damage. This method obviously requires much more extensive hotbed facilities than if the plants are only started in hotbeds and then transplanted to coldframes. The scarcity of manure may necessitate the use of other means of heating the beds.

The experiments at Cornell University referred to above also showed very strikingly the increase in the stunting effect of transplanting upon plants progressively larger in size. If plants are to be spotted or otherwise transplanted before being taken to the field, this should be done just before the first true leaf unfolds from the bud between the two seed leaves or cotyledons. It is especially important that seedlings standing very thickly be pricked out promptly lest they become tall and spindling and difficult to spot without breaking. Furthermore, a disease called "damping off" attacks the seedlings more seriously when they are crowded in the seedling row.

GROWING PLANTS FOR TRANSPLANTING

In the Northern States, where the winters are too severe for overwintering cabbage plants in the open, fall-grown plants can be overwintered in coldframes and set in the field early in the spring, but it is not a very common practice. The production of plants of proper size in the fall and carrying them over winter are both attended by considerable hazard on account of unpredictable and severe weather conditions. Generally such overwintered plants are not enough earlier than spring-grown plants to justify the hazard and the expense of producing and carrying them over winter.

In growing spring plants for an early market crop in the North it is necessary to start them under glass very early in the spring. Greenhouses or sash greenhouses are the best plant-growing structures, but standard greenhouses are too costly to use for early plant growing alone, although they can be used profitably for this purpose if used for the growing of other crops at other seasons of the year. As the greenhouse operator who may wish to grow some early cabbage is doubtless already familiar with the fundamental operations in producing plants of many kinds, no space need be devoted here to the elementary steps of growing cabbage plants in greenhouses. The construction and management of greenhouses and sash greenhouses is too large a subject and too highly specialized to be included in this circular, but information on that subject may be found in Farmers' Bulletin 1318, Greenhouse Construction and Heating (*3*). However, attention may well be given to the construction and use of hotbeds and coldframes for growing cabbage plants.

LOCATION OF HOTBEDS AND COLDFRAMES

Hotbeds and coldframes should be conveniently located so that they can easily be given the close attention they require. They should be in a place protected from cold winds by buildings, hedges, or other barriers; they should be on a well-drained, slight slope, preferably to the south or east, and where they can be easily watered when necessary.

MATERIALS

Experiments conducted by Comin and Sherman (*12*) in Ohio have shown that for growing cabbage plants glass is a better cover for hotbeds or coldframes than any substitute that has been devised. The substitutes are much lighter and easier to handle than glass, but they have some shading effect upon the plants and are not quite so effective in developing and maintaining satisfactory temperatures in the beds. The substitutes that are lower priced than glass are so short-lived that in the long run they are no cheaper. Those substitutes which do have good lasting qualities are, at this writing (1932), too expensive to replace glass satisfactorily. Furthermore, cabbage plants grown under common glass were larger and more vigorous at transplanting time and produced larger early yields and total yields than plants grown under any substitute. Earliness is a very important factor in the early market crop, and a reasonable expense in producing plants is justified in order to attain it.

Many questions have been asked recently about the special value of those kinds of glass which transmit the ultra-violet rays of sunlight and whether there are particular advantages or dangers attending their use in growing plants. Extensive studies at various institutions (*1*, *2*, *14*) indicate that the ultra-violet rays of sunlight have no appreciable effect on the size, form, or rate of growth of plants. Experiments carried on by the United States Department of Agriculture (*7*) show that common glass is quite as good for growing a variety of vegetable plants in coldframes as are the various kinds of glass that transmit ultra-violet rays. The ultra-violet glasses appear entirely satisfactory, however, their only probable disadvantage being their higher price.

Muslin is widely used as a coldframe cover for growing certain plants, but is not recommended for hotbeds for starting early cabbage in the more northern States because the plants must be started early while the weather is still so cold that muslin is not satisfactory.

Standard sash can be obtained glazed and painted complete for $3 to $4 each, depending on details of construction, quality of materials, and the distance they must be shipped. Sash can also be obtained painted but unglazed or unpainted and unglazed, the painting and glazing to be done by the buyer. If the cost of labor is considered, there is but little, if any, saving in buying unpainted, unglazed sash. Of course, if glazing and painting can be worked in along with other winter work for little or no additional outlay of money, it may pay to purchase the incomplete sash.

Sash with lapped glass is preferred to that with butted glass for hotbeds, but for coldframes butted glass is considered satisfactory. Butted glass usually leaks a little, and it is more difficult to replace broken panes than if the glass is lapped. Sash with three rows of 10-inch panes is better than that with four or more rows of smaller panes, because there are fewer bars which cut off part of the light. On the other hand, as breakage of large panes is more expensive than that of small panes, if the sash is not carefully handled, the cost of maintenance will be a little higher.

The frames should be built of rot-resisting wood, such as cypress or redwood, which will last several years. Pine boards rot very

quickly and are rarely good for more than one or two seasons. Permanent beds may be built with brick or concrete walls.

In regions of mild climate where only slight protection of the plants is needed muslin is successfully used as a cover for both hotbeds and coldframes. If there is any doubt about its adaptability to specific conditions and requirements, a careful comparison on a limited scale with glass should be made before depending upon it entirely.

CONSTRUCTION OF MANURE-HEATED BEDS

The most satisfactory size of bed is one that will be exactly fitted by any desired number of standard sash. Standard sash are 6 feet long and 3 feet wide, so the bed should be 5 feet 10 inches wide, outside measurement, and any convenient length.

In the milder parts of the Northern States a manure-heated bed may be constructed entirely on top of the ground. (Fig. 11.) A flat, well-packed pile of heating manure, about 9 to 10 feet wide, 3 to

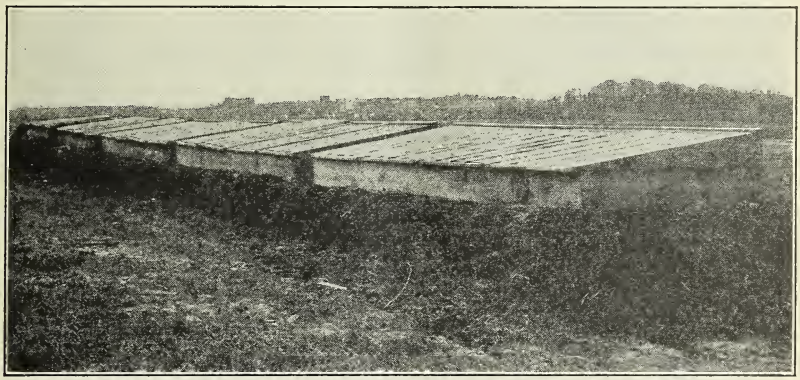

FIGURE 11.—Hotbeds constructed upon a flat, low pile of manure

4 feet longer than the frame to be used, and 18 inches to 2 feet high, is prepared. The frame is then set on the center of this pile of manure, soil placed in the frame, the sash put on, and the outside of the frame well banked with manure. This procedure saves the labor of digging a pit, but requires considerably more manure and is not suitable in very cold regions.

Shortly before the construction of the bed is started an adequate supply of fresh horse manure should be uniformly and compactly piled near the location of the bed. When the manure first starts to heat it should be mixed and repiled. Two or three days later the pit for the manure should be dug [5] and the manure placed in it as follows: The pit should be 7 feet wide, a foot longer than the frame, and 2 to 2½ feet deep. The farther north and the colder the region the deeper the pit should be, so as to hold more manure for furnishing more heat. The warmest part of the pile of manure should be

[5] In the more northern locations where the soil is usually deeply frozen at the time for constructing the hotbed, the pit may be dug the preceding fall and filled with cornstalks or straw, or covered in some convenient way to prevent the accumulation of ice in the pit. The coarse filling material can be easily removed, avoiding the difficulty of digging in frozen soil. The soil for the beds should be protected from freezing by covering the pile with manure or similar material.

placed in the bottom of the pit, and that which is cooler near the top. Successive layers of 3 or 4 inches of manure should be spread in the pit and thoroughly tramped down before more is added. If the manure tends to be dry, a sprinkling can of water should be added to each 2 or 3 linear feet of bed to prevent the manure from "burning." After 18 inches to 2 feet of manure have been thoroughly packed in and leveled across the top the frame should be put in place, the manure extending 6 inches beyond the wall of the frame on all sides; then 4 or 5 inches of moist, rich, light, disease-free garden soil

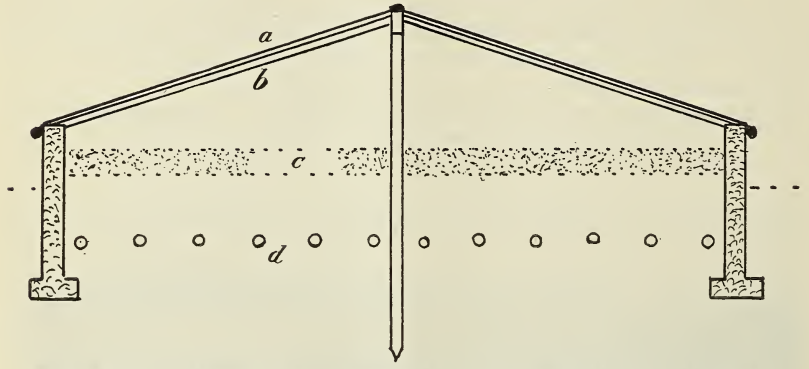

FIGURE 12.—Cross section of pipe-heated bed with pipes buried in the soil, heat being supplied from a boiler: *a*, Canvas or muslin cover; *b*, crosspieces supporting cover; *c*, special soil; *d*, heater pipes. Width of bed, about 12 feet

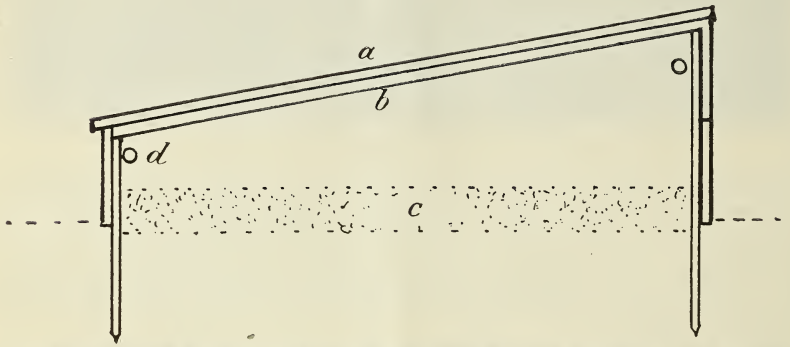

FIGURE 13.—Cross section of frame provided with two lines of heater pipes for use in case of low outside temperature: *a*, Glazed sash; *b*, crosspieces to support sash; *c*, special soil; *d*, heater pipes. Outside width of bed, 5 feet 10 inches

may be placed on top of the manure within the frame, the frame covered with sash, and the outside of the frame well banked with manure and soil in order to retain the heat. The front of the frame should be 6 to 8 inches above the soil and the back 12 to 14 inches high.

Steam-heated or hot-water-heated beds (figs. 12 and 13) are replacing manure-heated beds in many localities where large quantities of plants are needed and where the manure supply is inadequate or expensive. Encouraging results have been obtained with electrically heated beds in localities where current can be purchased below 3 cents per kilowatt-hour. The first cost of beds of these types is

appreciably more than that of manure-heated beds, but subsequent labor and maintenance costs are less, because they do not have to be constructed new every year. The construction of pipe-heated beds is a subject requiring more attention than can be devoted to it in this circular. Growers who are especially interested in constructing such beds should write to their own State agricultural experiment station or to the United States Department of Agriculture for information.

CONSTRUCTION OF COLDFRAMES

Coldframes are constructed essentially the same as hotbeds, except that they are usually less permanent and no artificial heat is provided. The sun is the only source of heat, and the glass or other

FIGURE 14.—Muslin-covered coldframes. Note the pipe for supplying water

cover is designed to retain the accumulated heat sufficiently to promote growth and protect the plants from frost during occasional brief periods of cold weather. Coldframes will not long maintain temperatures high enough for growth or even above freezing when the outside temperature is much below freezing. Temperatures remain low during periods of cloudy weather.

The frames and sash described for hotbeds may be set directly on the surface of a well-prepared soil, thereby serving as a coldframe. Generally, however, coldframes are constructed upon a much more extensive scale than hotbeds. Since they are not used during the summer, they are built so they can be dismantled easily and stored away so the land can be used for other purposes. (Fig. 14.)

A "knock down" type of frame that is very extensively used is built simply of two parallel lines of boards, firmly supported on edge by stakes driven into the soil, and with boards across the ends to complete the inclosure. The frames generally lie east and west, with a 12-inch board forming the back (north side) and a 6-inch

board in front (south side). If standard sash are to be used, the back and front boards are 5 feet 10 inches apart and have no pieces connecting them across the top.

If cloth covers are to be used, the beds may be as much as 7 or 8 feet wide. (Fig. 14.) In this event, the backboard should be 15 to 18 inches high to give adequate slope to the cover. Light crosspieces connecting the front and back boards are necessary every 3 or 4 feet to keep the cloth from sagging down on to the plants, and to facilitate rolling back the cloth when the beds are uncovered. Cloth-covered frames are also built 12 to 14 feet wide, with both lines of boards only 6 to 8 inches high and a ridge along the middle, about 2 feet high, supported on stakes. (Fig. 15.) The muslin is firmly held to the ridge or high north side by nailing laths over one edge

FIGURE 15.—Muslin cover of a 12-foot frame rolled up to center ridge

of the muslin; it is then stretched over the bed and held at the lower sides by the weight of poles or strips of wood fastened to the edge of the cloth or held inside a hem. The cloth is held over the end pieces of the bed by loops of cord hooked over nails.

There are methods of treating cloth to make it waterproof, but these treatments are of questionable advantage. If a good grade of muslin is used and it is thoroughly dried before being put away after use each season, it should last for many seasons. Untreated cloth is lighter, more pliable, and easier to handle than treated cloth.

MANAGEMENT OF HOTBEDS AND COLDFRAMES

The temperature of the soil should be determined with a dependable thermometer. Two or three days after the manure hotbed is made the temperature may rise to 90° F. or higher. The seed should not be planted until the temperature subsides to about 80° to 85°, which is usually two or three days later. After this time, a moderate heat, about 65° to 75°, should be maintained for several weeks. If

the bed is heated by flues or pipes, the temperature can be controlled at will, and planting may be done whenever it is desired.

The principles governing proper management of hotbeds are the same for all kinds, except that the temperature of manure-heated beds must be controlled entirely by manipulation of the sash and covers, whereas in flue-heated or pipe-heated beds the source of heat can be controlled. Keeping the proper temperature is but one of the very important things that can be learned thoroughly only by experience.

Beds should be watered only in bright weather, preferably in the morning, when it is warm enough to leave the covers off for a few hours so that the water will dry off the plants and the surface of the soil before the covers need to be replaced. Excess water on plants or soil is conducive to the spread of disease, as is also an excessive

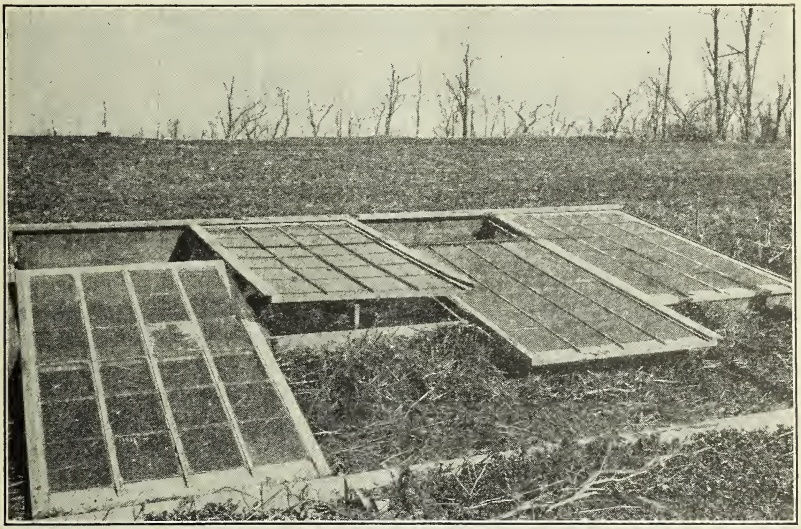

FIGURE 16.—Ventilating hotbeds by partly removing the sashes or propping them up

humidity of the air within the bed. The proper watering of plants requires more judgment and skill than an inexperienced person would suppose. There is more danger of watering too much than too little. Good soakings of the soil at longer intervals are better than frequent light waterings because the latter wets the plants and soil surface too often. Insufficient water obviously checks the growth.

Ventilation is another matter requiring some experience and good judgment in order to be properly done. Varying numbers of sash may be raised slightly at the lower edge or at the side at intervals along the bed, as required, and held open by notched boards or any convenient support. (Fig. 16.) With increasing outside temperature the sash must be opened more. In windy weather the openings should be smaller and fewer than on quiet days, and the openings should be to the leeward of the wind so that strong drafts will not sweep over the plants.

Muslin covers need to be opened less frequently than glass ones because some ventilation takes place through the cloth. Varying

amounts of ventilation are given by rolling up the cover the required distance from the lower edge.

When outside temperatures much below freezing are liable to occur, the glass or cloth covers should be further covered with hotbed mats, straw, pine needles, or similar material. Sash, other covers, or straw can be kept from blowing off the beds by laying heavy boards or poles across them or by stretching stout wires lengthwise of the beds, fastening them securely to stakes at the ends.

The management of coldframes is essentially the same as that of hotbeds except that coldframes require a little less attention during the day and may require more extra covering in cold weather. The absence of artificial heat is mainly responsible for this difference.

SOWING SEED AND SPOTTING PLANTS

In general, seed should be sown about seven weeks before time for transplanting to the field. The seed should be sown thinly, about three to four seeds per inch, in rows about 4 to 4½ inches apart, and covered about one-fourth inch deep. Sown at this rate a pound of seed will plant 35 to 40 sash and, under proper conditions, produce about 38,000 to 40,000 plants suitable for transplanting. Stated another way, it requires a little less than one-half ounce of seed per sash, and this should give at least 1,000 suitable plants. Considerable allowance for loss and some thinning has been made in these calculations. By sowing more thinly, so that there is less crowding and all plants have a better chance to develop fully, a pound of seed will furnish plants for 4 acres, but it is safer to sow a pound for each 3 acres and then pull out the weaker plants and thin down bunches of plants that stand too thick for good development.

If prospects of fancy prices for extra-early cabbage justify special efforts to produce large plants (6 to 8 inches high) for setting in the field, then "spotting" the plants about 3 by 3 inches would doubtless be more practicable. Attempting to sow thinly and subsequently further thinning the plants to such a spacing (250 to 300 plants per sash) would be too extravagant of seed and labor. Furthermore, such plants had better be produced in a greenhouse or sash greenhouse.

HARDENING OFF PLANTS

It is best to maintain an uninterrupted, moderate rate of growth until the plants are nearly large enough to set in the field (about 4 inches high). They should reach this particular size about 10 days before time for transplanting; during these last 10 days growth should be slowed down by gradually exposing the plants to lower and lower temperatures, also by gradually withholding water, taking care to avoid wilting the plants or allowing them to be damaged by cold. Some experience is necessary to accomplish this properly. Once the plants are hardened, care should be taken to keep them so until they are set in the field. Recurring high temperature or high moisture content that would stimulate growth may result in the hardiness being lost. Hardy plants will become tender again in about the same length of time required to harden them if they are subjected to conditions suitable for growth.

This process of checking growth hardens the plants, making them resistant to cold, somewhat resistant to wilting, and better able to

withstand the shock of being transplanted to the field. New roots form more quickly on hardened plants, and vigorous growth is resumed sooner. These desirable effects upon growth are of quite as much importance as cold resistance. The leaves of a well-hardened plant are thicker, stiffer, and have a heavier bloom than those of a nonhardened or tender plant. A tinge of red may develop at the edges of the leaves and along the stems. The stems are stockier, thicker, and firmer.

SOILS

There is less variation in the classes of soil suitable for growing the early market cabbage crop in the North than in growing cabbage in the South. On account of the relative earliness in the spring when the plants are set in the field, it is of primary importance that an "early" piece of land be used. Light or medium-light soils such as sandy soils or sandy loams are distinctly better than heavier soils such as loams or clay loams. The lighter soils are usually better drained and, because of lower water content, can be worked earlier and are definitely warmer than a heavy soil that retains large quantities of water.

MANURE

Comin and Bushnell (*11*) and Gourley and Magruder (*15*) in Ohio and Hartwell and Damon (*17*) in Rhode Island have shown that large applications of stable manure alone (16 to 30 tons per acre) produced smaller and less profitable yields than applications of 1,200 to 1,800 pounds of a high-grade complete fertilizer together with green-manure crops. The complete fertilizer used in the Ohio experiments was a 4–10–4 and that in the Rhode Island experiments an 8–12–4.[6] The best yields in both regions were obtained from manure, plus commercial fertilizer, plus green-manure crops. In Rhode Island 5 to 8 tons of manure plus fertilizer was better than 30 tons of manure alone. In Ohio 16 tons of manure, plus complete fertilizer, plus green manure was but very little better than complete fertilizer and green manure. There was, therefore, but little return from the manure in this combination. Four or five tons probably would have been more profitable.

In studying the amounts of fertilizer and manure required for several crops, including cabbage, over a period of 13 years, White and Boswell (*29*) in Maryland obtained results in agreement with those discussed above. The highest yields of cabbage were obtained with 1,500 pounds of complete fertilizer and with 6 tons of manure plus 750 pounds of fertilizer. The latter treatment gave but little higher yields than 1,500 pounds of fertilizer and cost more to apply. The final net money value is slightly in favor of 1,500 pounds of fertilizer. Twelve tons of manure annually produced high yields, but the cost made it the least profitable treatment. Even though as light applications as 2 tons of manure plus 250 pounds of fertilizer produced low yields, the increase in net value above that of untreated plots was greater than the increase when 12 tons of manure was used.

[6] 8 per cent nitrogen, 12 per cent phosphoric acid, 4 per cent potash.

Experiments conducted by Mack (*20*) in Pennsylvania showed that, over a period of 10 years, 1,200 pounds of 5–8–7 fertilizer produced higher yields than 20 tons of manure.

Although these four experiments were carried out under widely different conditions, these general conclusions should hold: The net value of small quantities of manure (4 to 6 tons per acre per year) plus commercial fertilizer is clearly greater than large quantities of manure (16 to 30 tons) alone. Green-manure crops and plenty of commercial fertilizer must of course be used. Good yields of cabbage can be built up and maintained profitably without animal manures. If manure is available it can be used most profitably in moderate quantities, supplemented with commercial fertilizer.

COMMERCIAL FERTILIZERS

The analyses of the fertilizers used in the Northern States tend to be a little lower in nitrogen than those used in the South and range from a 5–8–5 or 5–8–7 on the heavier or warmer soils to a 7–6–5 on lighter soils and in regions of late cool weather where an abundance of available nitrogen needs to be supplied. Experiments in widely separated places are consistent in showing the need for a complete fertilizer and that complete fertilizer with cover crops or with small amounts (4 to 5 tons) of manure is much more profitable than large quantities (20 to 30 tons) of manure alone.

Exact analyses can not be recommended because requirements vary in different localities. It should be said, however, that changes of only 1 per cent in the analysis of a fertilizer are hardly worth while in making practical trials. If cabbage grown with 1,000 to 1,200 pounds of a 4–8–4 or 5–10–5 fertilizer shows a need for more nitrogen, as indicated by poor color, a change should be made to a 7–8–5 fertilizer at least, or the basic application may be supplemented by top-dressings of nitrate of soda and sulphate of ammonia, as described on pages 28 and 29. About 1,200 to 1,500 pounds of complete fertilizer per acre is usually adequate if supplemented with successive applications of 150 to 200 pounds of a mixture of nitrate of soda and sulphate of ammonia as needed.

In the North the complete fertilizer is usually all applied just before transplanting. Quantities up to 1,000 pounds per acre may be applied in a broad strip and thoroughly mixed with the soil where the rows are to be. If more than 1,000 pounds per acre is to be applied, the amount in excess of 1,000 pounds should be broadcast unless a total of a ton or more is to be used, when the entire amount should be broadcast. Broadcast applications should be made after plowing but before disking or harrowing in order to thoroughly mix the fertilizer with the soil as deeply as possible.

A discussion of the methods of applying fertilizers is given on page 29.

HARVESTING AND HANDLING

The methods of harvesting and handling the early crop in the North are essentially the same as for the crop in the South (p. 30). In general, however, the northern crop is shipped shorter distances, and a much larger proportion of it is marketed locally or within trucking distance.

LATE OR MAIN-CROP CABBAGE

GROWING PLANTS FOR TRANSPLANTING

Plants for the late or main crop are grown in beds in the open essentially as described for the South (p. 23) except that the seed is sown in the late spring or early summer instead of in the fall. Recommendations made with reference to fertility of the plant bed in the South apply here as well, although there is no danger from winter injury nor premature flower-stalk formation. Plants grown very rapidly may be spindling and too tender to well stand the shock of transplanting. Plants grown at a moderate rate, which are stocky and firm, will not wilt so badly upon transplanting as will very rapidly grown plants. Well-grown plants also produce new roots and start growth in the field more quickly.

Seed should be sown five to six weeks before time for transplanting in the field. Open plant beds are satisfactory if the cabbage maggot is generally absent. In regions where this insect is prevalent, the plant beds may be kept covered with cheesecloth to prevent the adult insect laying eggs near the young plants. (See Insect control, p. 50.) Frames may be constructed like coldframes and placed over the beds after the seed is sown. Cheesecloth with 20 to 30 threads per inch makes a satisfactory cover. This gives some shading and causes the plants to be a bit more soft and succulent than when grown in the open. The cloth should be removed from the bed 6 to 10 days before pulling so that the plants will become somewhat hardened.

Experiments by Myers (*22*) in Pennsylvania showed that the largest plants in the plant bed produced the highest yields of late cabbage. The approximate yields produced by plants of different sizes, expressed as tons per acre, were as follows: Large, 21 tons; medium, 18 tons; small, 13 tons; ungraded plants, or "run of the bed," 18 tons. Therefore, for the late crop, it appears worth while to discard the small plants. Some excess of plants should be grown to insure an ample supply, and only the plants of medium or large size should be transplanted.

SOILS

Since most of the growth of the late crop of cabbage must be made during the summer when rainfall is often light and there is danger of drought, the heavier types of soils such as loams and clay loams are best. These soils retain moisture better than light soils and support growth better through the somewhat dry summer months. Another reason for the preference for loams and clay loams is their superior fertility. Early cabbage is usually of comparatively high value, while the late product brings lower prices. At high prices for the early crop, a grower is justified in using the very large quantities of fertilizer needed on some of the light, poor soils that have the physical characteristics necessary for earliness. But profitable yields of late cabbage might not be, and usually are not, produced on such soils. Production costs per ton must be kept down.

Late cabbage is grown on muck soils to a considerable extent.

MANURES AND FERTILIZERS

Recommendations upon the use of manure for the early crop (pp. 41 and 42) hold equally well for the late or main crop. As a

matter of fact, most of the experimental evidence concerning the value of manure on cabbage has been obtained in connection with the main crop.

Whereas nitrogen is the most-needed constituent in early crop fertilizers, experiments on later cabbage have shown that only moderate amounts are required. No effort is made to force the late crop into such rapid growth as the early crop; furthermore, during the growing season of the late crop the soil is warmer and better aerated and so contains more available nitrogen than it does early in the spring.

Late or main-crop cabbage is grown on soils of generally higher natural fertility than much of the early market crop, and in a rotation in which considerable organic matter is turned under. Consequently, less nitrogen needs to be applied in commercial form. Mack (*20*) in Pennsylvania has shown phosphorus to be of great value. Fertilizer recommendations for various parts of the country are in general agreement. It is assumed that a reasonable supply of organic matter will be maintained in the soil, either by manure or by turning under green-manure crops or both.

A 4–12–4 or 5–10–5 fertilizer is satisfactory in most instances. On slightly lighter soils, a 7–6–5 should be used; but soils requiring such treatment are not the most satisfactory. On the more fertile soils 600 to 1,000 pounds are commonly used and 1,000 to 1,500 on the less fertile. Early in the season, a top-dressing of 150 to 200 pounds of a half-and-half mixture of nitrate of soda and sulphate of ammonia should be given if the plants do not start growth satisfactorily. In dairy regions where plenty of manure is used, 500 to 600 pounds of 16 per cent superphosphate may be the only additional fertilizer required.

On newly developed muck lands manure usually gives a substantial increase in yield for the first few years. Later, however, the benefits of manure alone are less pronounced. Experiments carried on by the United States Department of Agriculture [7] on new muck at North Liberty, Ind., showed an 8-ton increase in yield of cabbage from applying 15 tons of manure per year. On old muck near South Bend a similar amount of manure gave yield increases of only 2.5 tons. In the former experiment, 200 pounds of muriate of potash gave practically the same yield as the manure, while at South Bend the potash plots yielded slightly more than the manure. Considering the relative cost of manure and of potash, the latter is usually the more profitable to use.

Experimental results obtained with fertilizers on muck soils by the United States Department of Agriculture have been confirmed by extensive experience. On such soils, cabbage requires a fertilizer relatively low in nitrogen but high in phosphorus and potash. Potash seems to be the required fertilizing element most deficient in muck soils. An 0–10–16 fertilizer is widely used and gives good results. A mixture of approximately this analysis is readily made from 800 pounds of 16 per cent superphosphate and 400 pounds of muriate of potash. If results show the need for nitrogen, 100 pounds each of nitrate of soda and sulphate of ammonia may be included in

[7] Unpublished.

the mixture, or may be mixed separately and added as a top-dressing. If they are included with the superphosphate and potash, approximately a 2½–9–15 mixture is obtained.

It should be emphasized that the individual grower must carefully note his results with various fertilizers and add more of whatever materials appear to be lacking. In some instances 4 to 5 per cent of nitrogen is needed in mixtures otherwise similar to those recommended above. It is not possible to make recommendations that will be best for all muck soils.

Complete fertilizers may be applied to the soil broadcast after plowing but before disking or harrowing. If a row distributor is used, the fertilizer must be thoroughly mixed with the soil as deeply as possible before planting. Most of the roots of the cabbage lie between 3 and 12 inches below the surface, and obviously the fertilizer should be where the roots will reach it.

HARVESTING AND HANDLING

Late cabbage is harvested only after the heads have become hard. Generally, the heads should be trimmed rather closely, to three or four tight wrapper leaves, this trimming being done as the cabbage is cut in the field. The heads are usually hauled in bulk from the field to market, to the storage house, or to the sauerkraut factory. Precautions should be taken to prevent unnecessarily rough handling and bruising of the product, since damage may result in serious spoilage. Rough handling at least mars the appearance of the heads.

CABBAGE FOR SAUERKRAUT

The varieties most commonly used for sauerkraut are Glory of Enkhuizen, Late Flat Dutch, All Seasons, and in some regions Copenhagen Market. These varieties are of the so-called "domestic" type, which becomes moderately hard but can not be successfully stored. Danish Ballhead and Wisconsin Hollander are of the Danish type, which is rarely used for sauerkraut.

When cabbage is harvested for immediate delivery to the sauerkraut factory, it should be trimmed closely by removing all loose and wrapper leaves. It must be fully developed or mature. Green cabbage produces sauerkraut which is off grade in color and texture.

STORAGE

Danish Ballhead is the variety grown for storage except in areas which are infested with cabbage yellows, where Wisconsin Hollander may replace it. This latter variety is similar to Danish Ballhead (p. 13), but is resistant to cabbage yellows.

To be successfully stored, cabbage must be quite free from disease of any kind and should be reasonably free from mechanical or insect injury. All loose leaves should be removed. It should be stored at a temperature of 33° to 35° F. and a relative humidity of 80 to 85 per cent. As cabbage freezes between 31° and 31.5° F., the temperature of the storage house should not be allowed to fall below 32° for more than a few hours, and preferably not at all. Mild freezing is not particularly destructive, but should be avoided, especially in house or cellar storage.

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COMMERCIAL

The most satisfactory storage conditions are afforded by specially constructed, frost-proof storage houses (fig. 17), and it is in such structures that most of the commercially stored cabbage is held. Large quantities are also held in commercial cold-storage rooms.

The best type of cabbage storage house is of well-insulated, practically frost-proof construction. The roof as well as the walls should contain some effective insulating material, such as sawdust, shavings, or some of the prepared insulating papers or other materials commonly used by the building trades. Large dead-air spaces between walls have been found to be relatively poor in insulating value on account of the convection currents which develop within them, permitting loss of heat from one wall to the other. Windows and doors should be shuttered.

FIGURE 17.—Exterior of a satisfactory type of cabbage storage house

Ample ventilators in the roof should be provided for the exit of warm and moisture-laden air, and they should be equipped with dampers that can be controlled from the floor. Cold air from the outside should be admitted when needed through screened openings near the floor. These also should be equipped with easily controlled dampers.

Large dugouts or shallow earth-covered banks or storage cellars are successfully used if adequate ventilation is provided.

In practically all instances the floor of the storage house is of earth. This is desirable if the location is well drained, since it helps maintain the high humidity of the air that is necessary to prevent serious wilting of the cabbage. As a muddy floor will cause too high humidity in the house, precautions should be taken regarding drainage.

The bins or tiers of shelves should be built on either side of a driveway that should run through the center of the house and be wide enough to accommodate a wagon and team or a motor truck. Bins should be no more than 4 feet wide, with a 6-inch space between bins. All bins, or shelves, should be of open construction, to permit

the greatest possible freedom of air circulation. (Fig. 18.) The heads should be piled no more than 6 feet deep in the bins. Laying the heads two or three deep upon heavy shelves is satisfactory, but placing them on demountable latticelike shelves in a single layer (fig. 19) is preferable, because it affords better circulation of air, and there is less bruising and less danger of heating or decay. The construction of shelves is, of course, more expensive per ton of storage capacity than is the construction of bins. An air space of 8 to 10 inches should be left between the walls and all bins or shelves to avoid frost and afford air circulation.

As harvest time approaches, advantage of the cool nights should be taken to cool the storage house down to as near 33° F. as possible, keeping it shut during the day and open at night. This same procedure should be followed while the cabbage is being placed in storage. Later in the season the reverse may be necessary in order to afford needed ventilation and to prevent the house from becoming too cold. In very cold weather the house must be kept closed tightly except for such slight ventilation as is necessary. Oil or coke heaters usually are needed during the coldest weather to prevent freezing in the house. They are placed at intervals in the driveway or aisles of the house.

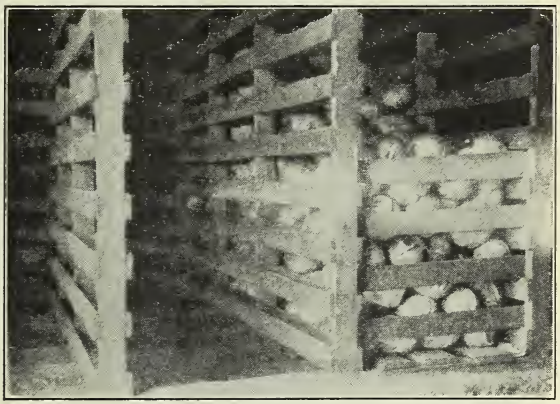

FIGURE 18.—Narrow bins with air spaces between them used for storing cabbage

FARM

On the farm small quantities of cabbage are often stored for the winter, or large quantities are stored for short periods by various methods that are sometimes fairly satisfactory but are considered less safe than the use of well-constructed houses.

For storing small quantities, the entire plant may be pulled from the soil and the outer leaves removed. The roots may then be set in moist soil in a coldframe or storage pen (fig. 20) with the heads as close together as possible. The frame or inclosure is then banked with soil and covered with sash, boards, poles, or other available material that will support a heavy thatch of straw.

The trimmed heads may be placed in a conical or a long narrow pile, then covered with 8 or 10 inches of straw and finally a layer of soil about 8 inches to a foot thick. If the pile is to be a large one, the cabbage should be placed about an upright A-shaped frame which allows some ventilation between the heads. Another method is to build the pile over a trench which is covered by heavy, widely spaced boards, the trench serving as a means of ventilation. (Fig. 21.) The ends of such ventilating trenches or frames should extend slightly

beyond the pile of cabbage and should be well covered with straw or similar material, but the passage of air should not be entirely stopped by the soil covering. The cabbage should be well covered

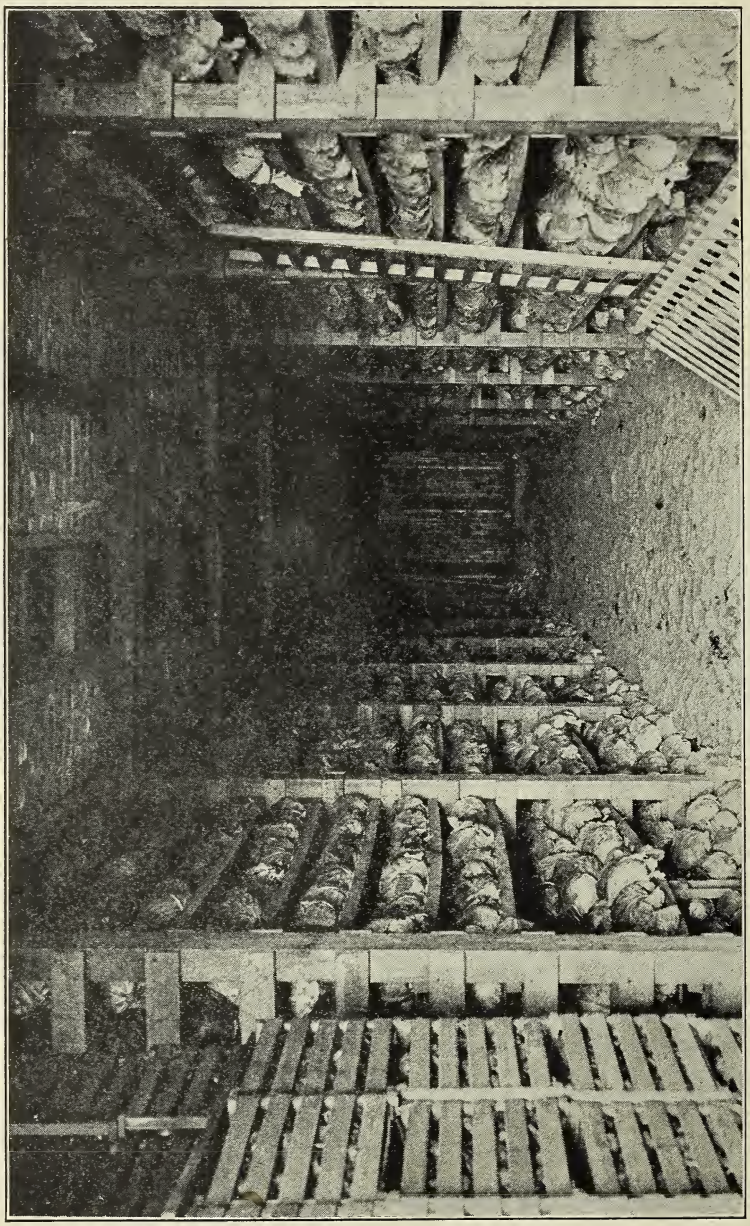

FIGURE 19.—Interior of cabbage storage house equipped with slatted removable shelves. The use of such storage houses is preferable to the use of bins

with both straw and soil. Sometimes, for temporary storage, the heads are spread upon straw in broad, shallow, well-drained pits and covered with straw or litter and soil.

These various pits are satisfactory only in mild regions or in instances in which the cabbage is to be removed from the pit before very cold weather. The difficulty of obtaining ventilation, the danger of loss through decay or freezing, and the probability of bad weather interfering with the removal of the cabbage from the pits all contribute to make this general method little more than a poor substitute for proper storage.

Well-ventilated cool cellars are satisfactory and should be managed according to the recommendations for storage houses.

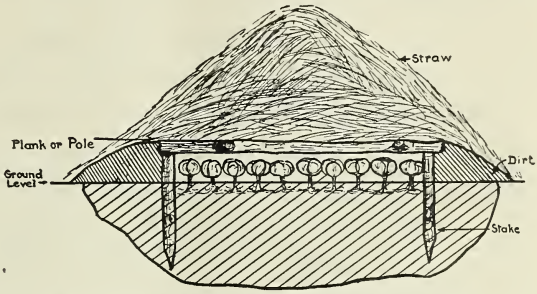

FIGURE 20.—Cross section of a cabbage storage pen made of stakes and poles and covered with straw

UNITED STATES GRADES

Standard grades have been established for Danish cabbage that has been stored, as well as for fresh market cabbage. Storage conditions and the handling of the product should be so carefully managed that the highest possible proportion of the stored product can be classed as United States No. 1 upon removal from storage. The

FIGURE 21.—A board-covered trench affording drainage and ventilation for a long pile of cabbage which will be covered with straw and soil

best profits can be made only upon a high-quality product, so those who store cabbage should be familiar with the specifications for the standard grades. Copies of these specifications can be obtained by writing to the Bureau of Agricultural Economics, United States Department of Agriculture, Washington, D. C.

INSECT CONTROL [8]

PREPARATION OF SPRAY AND DUST MIXTURES

In preparing spray mixtures for controlling insects the following method should be used: Half fill the spray tank with water, running it through a fine strainer. Put the required amount of the powder to be used in a bucket, add a little water, and work up a paste of the material, thoroughly wetting every particle of the powder. Add enough water so that the mixture can be stirred easily and then pour this through the strainer into the spray tank and add the remainder of the water required. If soap is added as a spreader, it should be dissolved in a small quantity of hot water, then added to the spray mixture. Thoroughly stir the whole mixture.

An easy way to prepare dust mixtures is to place the ingredients in a drum, barrel, or large can, together with a few stones about the size of a baseball, and close the container tightly. Then roll it a total distance of about 500 feet, turning it end over end a few times about every 50 feet. The container should be no more than one-half or two-thirds full of material, allowing plenty of space for the material to move about freely as the container is turned or rolled.

CABBAGE WORMS

The cabbage crop is subject to injury by several kinds of caterpillars, or "worms." This is particularly true in the winter-producing areas, where the cabbage looper, the common cabbage worm, the cabbage webworm, and the larva or worm stage of the diamond-back moth may attack the crop throughout the season.

Owing to the fact that there is danger to the consumer in the use of an arsenical or other poison on cabbage, the control of these worms presents a difficult problem. Arsenical dusts and sprays to protect the plants in the seed bed and the immature crop in the field may be used without danger to the consumer. The treatment of the crop with an arsenical or other poison as it approaches maturity, however, is likely to result in the presence of dangerous arsenical residues on the market product. The exact time when treatments with the poison should cease, so as to insure against an arsenical residue reaching the market on the cabbage, has not been definitely worked out. The period which must elapse between the last treatment and the harvest of the crop will depend upon several factors. Of these the principal one is weather conditions, since prevailing temperatures will affect the maturity of the crop, and rainfall will aid in the removal of objectionable residues. The type of cabbage grown must also be considered, as there is greater danger of an arsenical residue remaining on the loose-leaf kinds than on the closed-head types.

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[8] Prepared with the assistance of W. H. White, principal entomologist, in charge, Division of Truck-Crop and Garden Insects, Bureau of Entomology.

In view of this poison-residue problem definite recommendations for the control of cabbage worms can not be made to meet all conditions. After the crop has been treated with a poison, the grower should take every precaution to see that his market product is free from any residue which might subject the cabbage to seizure during interstate shipment, or on the local market, because of danger to the consumer. All leaves bearing any evidence of dust residue should be stripped from the head, and if this stripping is not sufficient to remove all leaves bearing residue then the heads should be carefully washed.

The following mixture will make a satisfactory dust: 1 pound of lead arsenate and 5 pounds of hydrated lime. The rate of application will depend upon the size of the plants but should average about 15 pounds to the acre for each application.

Another mixture consists of 1 pound of Paris green and 15 pounds of hydrated lime.

In applying the dust, every effort should be made to cover both surfaces of the cabbage leaf with a light, even coating of the dust mixture. This can not be accomplished by the "sack method" or "can-shaker method." A hand duster of the blower or fan type should be used on small acreages. For larger acreages a horse-drawn traction or power duster can be used to advantage.

If spraying is desirable, the following mixture may be used: 2 pounds of lead arsenate, 4 pounds of fish-oil soap or laundry soap, and 50 gallons of water. The rate of application should be 100 gallons of the spray mixture to the acre.

A traction or power sprayer is practically a necessity for applying a liquid spray, as the hand-operated sprayers can not be used economically on areas much larger than an acre.

It is a good plan to dip the plants in a poison mixture after taking them from the seed bed and before setting them in the field. This will protect the newly planted cabbage to a marked extent.

The object in the control of cabbage worms should be to keep down infestations. This can be accomplished to a considerable degree by cleaning up, directly after harvest, the cabbage remnants in the field and those of other crops, such as kale, broccoli, and turnips, all of which are hosts of the worms which attack cabbage. Do not wait for the worms to do considerable feeding before applying the first poison treatment.

CUTWORMS

Cutworms sometimes are very destructive to cabbage plants directly after these have been transplanted from the seed beds to the field. These pests can be controlled readily by the use of the following poisoned bait: 1 peck or 5 pounds of dry bran, one-fourth pound of Paris green, 1 pint of sirup or molasses, and 3 or 4 quarts of water; or, in large quantities, 25 pounds of dry bran, 1 pound of Paris green, and 15 to 20 quarts of sirup or molasses.

To prepare the bait:

(1) Thoroughly mix the poison with the bran. This is important. Each particle of bran must carry a little poison to get a good kill. When making small quantities one can mix the bait in a bucket with a paddle, adding the poison slowly and stirring the bran at the same time. A still more effective way is to mix the poison and bran with the hands, but since soluble arsenic is

absorbed to a slight extent through the skin, there may be some objection to this method. If the hands have any cuts, scratches, or other wounds, do not put them into the bait. When making large quantities mix the poison with the bran on some flat smooth surface, using a shovel and rake in much the same way as in mixing concrete.

(2) Mix the sirup with the water.

(3) Add the water and sirup solution to the mixture of bran and poison, stirring slowly all the time. Large quantities of water added at one time will wash the poison from the bran and the result will be an uneven mixture.

Caution.—Add only enough liquid to make a crumbly mass. It is a good plan to set aside a little of the mixture of dry bran and arsenic so that if too much water has been used this dry reserve can be added to bring the mixture up to the proper consistency. Large quantities can be made up in galvanized-iron or wooden washtubs and small quantities in buckets or similar containers.

Either broadcast the poisoned bait or sow it by hand along the rows or about the base of the plants. Do this late in the evening so that the bait will not dry out to any great extent before the worms get busy. Since many kinds of cutworms overwinter in the ground and start feeding as soon as the weather becomes favorable in the spring, it is a good plan to broadcast the poisoned bait over the field before the plants are set out.

Ten to fifteen pounds of the wet bait is enough for one application per acre. Where the bait is applied directly to the rows or hills a smaller quantity will be sufficient. It may require two or three applications at 2-day intervals to rid the field of the pest.

Warning.—A stomach poison for an insect is also poisonous to other animals and man. Keep the poison and poisoned-bran bait away from farm animals and irresponsible persons.

CABBAGE MAGGOT

The newly hatched cabbage maggot is a tiny white creature that easily escapes observation. It develops from eggs laid by an adult fly which somewhat resembles the common house fly in appearance but is smaller and of a grayish color. The eggs are laid just beneath the soil surface close to the young cabbage seedlings, and very soon after hatching the maggots attack the root and below-ground portions of the stem of the plants, eating away the outer layers just below the soil surface. Later, as the maggots become larger, they feed on the part of the stem deeper in the soil, and many burrow into the stem, but for the most part they feed on the roots, damaging them severely or entirely destroying them.

Maggot injury in the seed bed is usually first evidenced by certain plants becoming a lighter and more bluish color than others in the bed. In hot or dry weather these injured plants wilt readily, and many may die. Upon further examination it will be found that these plants can be drawn from the soil very easily because many of the roots have been destroyed. In some cases the roots will be almost all destroyed. In a large seed bed the injury usually appears in spots or patches. Most of the affected plants do not die but are severely stunted in the plant bed and may die after transplanting; at least they make such poor growth as to be practically a total loss.

Screening the seed bed is one of the best maggot-control measures. Before the seedlings are up, a coarse cheesecloth having 20 to 30 threads per inch is stretched tightly over the beds, preferably tacked to board frames at the edges of the beds, much like coldframes. The

cloth should be sewn together to make a single, insect-proof cover for each bed. If the beds are more than 6 feet wide, wires should be stretched tightly across or along the beds, attached to the top of the frames, to keep the cloth from sagging down on the plants. The frames should be banked slightly with soil, and the covers should fit tightly to prevent the entrance of any flies. The cover may be removed for the brief periods necessary for watering, cultivating, or weeding, but should be replaced as quickly as possible.

On account of the shading effect of the cloth, special precautions must be taken to avoid crowding the plants or promoting too succulent growth by means of rich soil or fertilizer. The cover should be removed a week or 10 days before the plants are to be set out, to harden them.

Some growers insist that plants grown without covers are sturdier and stand transplanting so much better than those grown under screens that they prefer other methods for control of the maggot.

Corrosive-sublimate solution is applied to the soil about the base of the plant at the rate of 1 gallon for each 20 to 40 feet of row, depending upon the age of the seedlings, the lesser amount being applied to the younger plants. The solution is prepared by dissolving 1 ounce of corrosive sublimate in about a half-gallon of hot water, then adding this concentrated solution to 10 to 12 gallons of cold water, and stirring thoroughly. This solution may be applied by any device that will deliver a small stream at the base of the plants in the rows in the seed bed. For very young seedlings, a solution of 1 ounce of corrosive sublimate to 15 gallons of water is safer. Corrosive sublimate is only slightly soluble in cold water. Care must be taken, as directed, to insure that it is all dissolved, else the solution may be too weak to be effective. Solutions should be prepared in earthenware, glass, or wooden containers, because they corrode metals. Galvanized cans or other metal equipment used to apply the solutions must be thoroughly rinsed immediately after being used, and the solutions must not be allowed to stand in them.

The time for the first application has no relation to the size of the plants but depends entirely on the appearance of the insect. In the Northern States where the cabbage maggot is injurious, the adult usually begins laying eggs about the time that European varieties of plums are in bloom. The actual date varies of course from year to year in one location, and from place to place in the same year. Careful inspection of the soil at the base of the plants should reveal the presence of eggs soon after the flies have begun to deposit them. Applications should begin with the first evidence of eggs and continue at intervals of a week to 10 days, unless the infestation is known to be light, when one or two well-timed treatments may give satisfactory control. Some experience is necessary to obtain the most efficient results.

Corrosive sublimate is very poisonous and must be handled with proper care.

HARLEQUIN BUG

The harlequin bug causes damage of commercial importance normally only in the Cotton Belt. It is a brilliantly colored red and black bug that sucks the sap from the leaves of cabbage and related

crops. The eggs are easily identified by their resemblance to white barrels with black hoops and a black spot in the position of the bungholes.

The harlequin bug can best be controlled by preventive measures indicated below. It is very difficult to kill it with any insecticide that does not injure the plant on which it is feeding. These preventive measures are adopting clean cultural methods, planting trap crops, hand picking the bugs, and spraying the nymphs with contact insecticides.

All remains of crops of cabbage or related crops should be completely plowed under promptly after the crop is harvested. Wild plants of the mustard family should be kept down as completely as possible. These weeds and remains of cruciferous crops afford favorite food and protection for the cabbage bug, prolonging its life and promoting its increase. In fact, any rank weed growth or rubbish may harbor the insects over winter. Good field sanitation is a material aid in controlling the pest.

The favorite food plants of the insects seem to be horseradish, mustard, rape, and kale. Early plantings of these crops may be made about the borders and at intervals through the cabbage field to attract the bugs that first appear. The bugs can then be killed by spraying with kerosene or otherwise destroying the plants upon which they have collected. The few bugs that escape the trap crops may be hand picked from the cabbage. A combination of trap cropping and hand picking has been proved thoroughly practicable and effective.

The conspicuous appearance and sluggish nature of the harlequin bug make it easy to capture. Hand picking by knocking the bugs from the plant into a shallow pan containing a small quantity of kerosene is useful. Close watch must be kept for the bugs that first appear. If these few are exterminated, the damage will be greatly reduced if not entirely prevented for the season, and but few bugs will appear later.

No insecticide which it is safe to use on a growing plant will have any effect on the adult bugs. Spraying is effective only in the young stages of the life of the bug, when it is still delicate and soft-bodied. During or just after the time that these soft-bodied nymph forms shed their outer coverings, they can be killed by a spray of 10 per cent kerosene emulsion, or a solution containing 1 pound of whale-oil soap to 4 gallons of water. Nicotine sulphate at the rate of 1 pint of 40 per cent nicotine-sulphate solution to 25 gallons of water should also kill the young nymphs. One pound of soap to 25 gallons of water will need to be added as a spreader or sticker. Pyrethrum extracts have about the same effect on the pest as nicotine and soap solutions.

ARSENICALS

Since the harlequin bug feeds entirely by sucking the juices of the plant from tiny punctures in the leaves or stems, any stomach poison such as lead arsenate or Paris green is without noticeable effect upon it.

Further information regarding the harlequin bug may be found in Farmers' Bulletin No. 1061, Harlequin Cabbage Bug and Its Control (*10*).

APHIDS OR PLANT LICE

The turnip aphid and the cabbage aphid are similar tiny, soft-bodied, sucking insects that can be controlled by contact poisons such as nicotine sulphate, but can not be controlled by stomach poisons. As in controlling all insects, it is especially important to start treatments as soon as the first infestation is evident. Controlling the first light attack is usually not very difficult; but if control measures are neglected until the field is heavily infested, the damage is certain to be serious and control measures will be of doubtful success. The infested leaves soon crumple and curl downward around the insects so that it is difficult to reach them with dust or spray.

The first few scattered infestations in a field can often be cleaned up by applying a 3 per cent nicotine dust to the infested plants with a hand-operated duster. If the field is of more than 2 or 3 acres and the infestation is general, horse-drawn or power dusters or sprayers can be used more efficiently.

The field may be sprayed with a nicotine sulphate-soap solution, made as follows: Three-fourths pint of nicotine sulphate (40 per cent nicotine), 2 pounds of soap, and 50 gallons of water. About 100 gallons of spray solution is required per acre for a uniform application. Thirty to forty pounds of dust per acre are needed. If the plants are small, or if only small infested areas are to be treated, obviously less material will be required.

DISEASE CONTROL[9]

Cabbage is subject to a number of diseases which may in large measure be avoided by proper attention to seed treatment, soil management, and choice of resistant varieties. Since the causal parasites of two important diseases, black leg and black rot, are often carried with the seed, it is advisable before the seed is sown to immerse it in a 1–1,000 solution of corrosive sublimate for 30 minutes and rinse it in clean water before drying. The seed bed should be rotated from year to year to avoid the initiation of disease from germs of the previous years, some of which may live over on old cabbage débris. It is also well to select a location for the bed which is not subject to flow of surface-drainage water from higher levels where cabbage or related plants have been grown previously. Where plants are started in hotbeds or coldframes the soil should be changed frequently, or the danger of soil parasites of cabbage should be removed by steam sterilization of the soil.

Rotation of the transplanted field is also paramount to continued successful cabbage culture.

BLACK ROT

Black rot is likely to occur wherever cabbage is grown. It also affects cauliflower, Brussels sprouts, kohlrabi, kale, rape, and a number of cultivated and wild plants of the mustard family. It is caused by bacteria which may live over in the soil at least one

[9] Prepared by J. C. Walker, agent, Division of Horticultural Crops and Diseases, Bureau of Plant Industry. For additional information on cabbage diseases see Farmers' Bulletin 1439, Diseases of Cabbage and Related Plants (*26*).

winter in the North, and are commonly carried with the seed. The black-rot germs gain entrance through the water pores at the edge of the leaf and travel through the water vessels, causing them to become black in color. The infected leaves show yellowing and dying of the tissue in characteristic, often V-shaped areas starting at the leaf margins and extending toward the midrib. As the disease progresses, leaves fall off prematurely. When the organisms have gained access to the main stem they travel upward and affect new leaves or enter the maturing head, causing the blackening of the veins sometimes throughout only a leaf or two of the head. One of the most serious phases of black rot is the fact that it opens up the way for and is usually followed by the common soft rot.

Black rot is checked by seed treatment and by rotation of seed bed and field. It should be borne in mind that other related plants harbor black-rot germs, and therefore the seed bed especially should not follow cauliflower, rape, or other members of the mustard family.

SOFT ROT

Soft rot, common to most vegetables after harvest, often causes heavy losses to cabbage in storage and transit. However, this germ enters only through wounds caused by handling, freezing, or another parasite such as the black-rot germ. It sometimes appears in the field before harvest, particularly where black rot has previously made headway.

Soft rot is so named because it consists of a softening of the tissues of head leaves and the core. This is usually accompanied by a repugnant odor.

The chief preventive measure for soft rot is care in handling the harvested crop to avoid unnecessary bruising and freezing injury. Control of black rot indirectly reduces soft rot. The crop from fields badly infected with black rot should be marketed for immediate consumption and not held in storage for any long period.

BLACKLEG

Blackleg is so named because the causal fungus commonly attacks the plant at the base of the stem and progresses downward, causing a decay of the outer tissues and depletion of the fine roots. The advanced stages result in a sudden wilting of the plant. The fungus may attack leaves, seed stems, pods, and seed, but the heaviest loss to the cabbage grower is that resulting from stem and root injury.

The fungus is seed borne and may also live over one year in the refuse of diseased plants. The precautions recommended in the case of black rot apply also in the case of blackleg.

CLUBROOT

Clubroot is a very widespread disease on cabbage and many other members of the mustard family. It is caused by a soil organism which attacks the roots and results in swellings or "clubs" of various sizes and shapes. This abnormal root growth retards top growth, and plants thus become stunted while eventually the reduced supply of water results in the wilting and collapse of the plant.

Clubroot is the most difficult cabbage disease to control. The organism is not seed borne, but it lives many years in the soil without the presence of a congenial host; therefore the ordinary rotation procedure is not helpful. In selecting the seed bed infested soil should be avoided. Plants should not be taken from a bed showing any disease, since even healthy-appearing plants may carry the disease germs to the field. A liberal application of hydrated lime well worked into the soil some weeks before transplanting usually reduces the disease.

YELLOWS

The yellows disease resembles black rot in that it causes a discoloration of the vessels and defoliation of the plant. However, the evidences of infection at the leaf margins are absent, since the parasite is a soil fungus which gains entrance through the root tips.

The yellows fungus, like the clubroot organism, is not seed borne but persists indefinitely in the soil. The disease increases in severity with the rise of soil temperature and thus is most acute in midsummer. Moreover, it is of little importance in the most northerly cabbage sections and on the winter crop in the South.

Fortunately, yellows has been controlled by the development of resistant varieties through the cooperative work of the United States Department of Agriculture and the Wisconsin Agricultural Experiment Station. Several of these have been developed to meet various needs. Some of the more widely used yellows-resistant varieties are described on page 15. Seeds of these are now listed by many seedsmen.

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